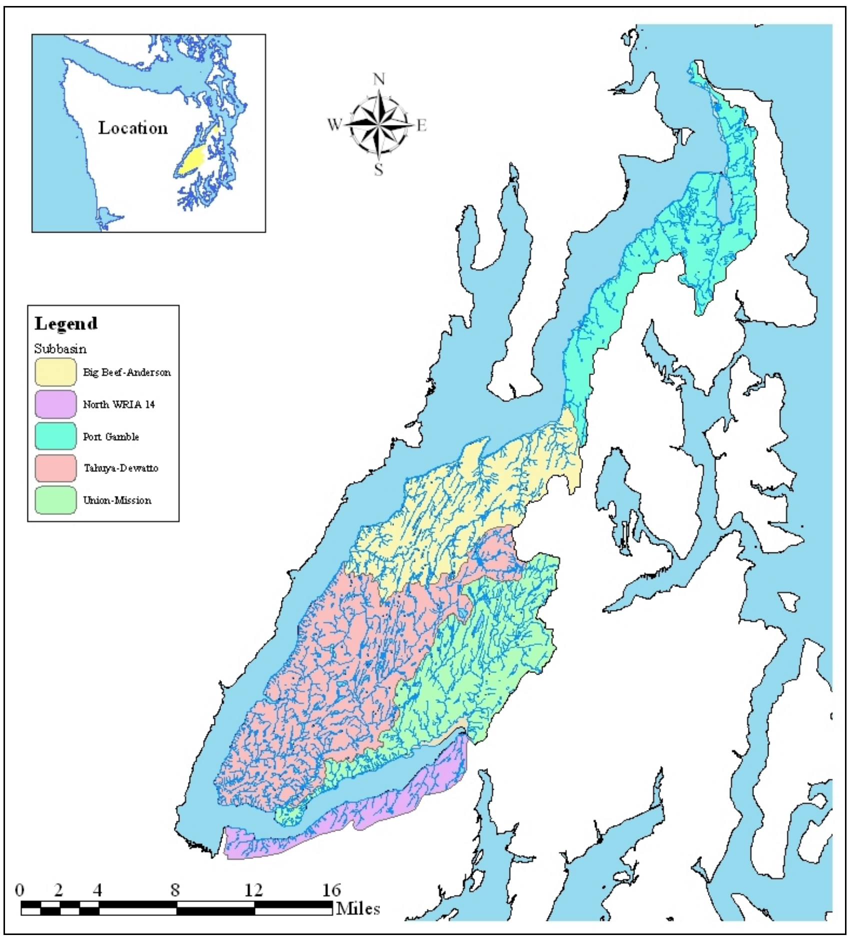
SALMONID HABITAT LIMITING FACTORS WATER RESOURCE INVENTORY AREAS 15 (WEST), KITSAP BASIN AND 14 (NORTH), KENNEDY-GOLDSBOROUGH BASIN



FINAL REPORT
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Coho salmon preparing to spawn in a tributary of the Tahuya River.
Photo courtesy of Marty Ereth, Skokomish Tribe.

The Water Resource Inventory Areas 15 (West) and 14 (North) salmonid habitat limiting factors report could not have been completed without considerable contributions of time, data, and effort from the following people who participated in various capacities on the Technical Advisory Group (TAG):

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ABBREVIATIONS AND ACRONYMS

‰: Parts per thousand
7-DADMT: Seven-day average daily maximum temperature
AIMT: Annual instantaneous maximum temperature
CFS: Cubic Feet per Second
CREP: Conservation Reserve Enhancement Program
CRP: Conservation Reserve Program
DBH: Diameter at Breast Height
DO: Dissolved Oxygen
DOE: Washington Department of Ecology
EQIP: Environmental Quality Incentives Program
ESA: Endangered Species Act
FSA: Farm Service Agency (USDA)
GPM: Gallons per Minute
HCCC: Hood Canal Coordinating Council
HCSEG: Hood Canal Salmon Enhancement Group
IFIM: Instream Flow Incremental Methodology
KCD: Kitsap Conservation District
LB: Left Bank of stream (looking downstream)
LWD: Large Woody Debris
MCD: Mason Conservation District
NRCS: USDA Natural Resource Conservation Service (formerly SCS)
NMFS: National Marine Fisheries Service
NWIFC: Northwest Indian Fisheries Commission
PNPTC: Point No Point Treaty Council
RB: Right Bank of stream (looking downstream)
RCW: Revised Code of Washington
RM: River Mile
SASSI: Salmon and Steelhead Stock Inventory (WDFW 1992)
SaSI: Salmonid Stock Inventory (WDFW 1998-present)
SID: Washington Department of Fisheries, Stream Improvement Division
SSHIAP: Salmon and Steelhead Habitat Inventory and Assessment Project (NWIFC)
SRFB: Washington State Salmon Recovery Funding Board
TSS: Total Suspended Solids
USACE: United States Army Corps of Engineers
USDA: United States Department of Agriculture
USFS: United States Forest Service
USFWS: United States Fish and Wildlife Service
WAC: Washington Administrative Code
WAU: Watershed Administrative Unit
WCC: Washington State Conservation Commission
WDF: Washington Department of Fisheries
WDFW: Washington Department of Fish and Wildlife
WHIP: Wildlife Habitat Incentives Program
WRIA: Water Resource Inventory Area

EXECUTIVE SUMMARY

Introduction

This report describes and assesses riverine and nearshore salmonid habitat conditions along the east shore of Hood Canal (west Water Resource Inventory Area, WRIA 15), and the south shore of Hood Canal (north WRIA 14). This region extends from Foulweather Bluff in the north to the town of Union in the south. The report focuses on salmonid habitat conditions only; harvest, hatchery, and hydropower issues, while playing a part in the decline of salmonid populations, will not be discussed. These issues are being dealt with in other forums. In 1998, the Washington State Legislature passed Engrossed Substitute House Bill 2496 (later codified to RCW 77), directing the Washington State Conservation Commission in consultation with local, state, federal, and tribal agencies to identity habitat factors that limit salmonid production in watersheds throughout Washington State. This report was developed under this mandate and is intended for use in identification and prioritization of salmonid habitat restoration and protection projects within the report area. The report is not a salmonid habitat recovery strategy, although it could be a component of such a plan.

Habitat and Salmonid Production

The ecological characteristics of streams draining to the east and south shores of Hood Canal are largely the product of past glaciations. The topography of this area is relatively flat and dissected by numerous streams eroding sediments deposited and reworked by several glacial episodes. Numerous lakes and wetlands are present in depressions throughout the drainage network, providing important rearing habitat for juvenile salmonids, particularly coho salmon and cutthroat trout. The glaciers deposited large quantities of gravel that provide abundant salmonid spawning habitat in the low to moderate gradient streams draining this region. Groundwater travels freely through gravel lenses, maintaining streamflows during the dry summer months, and improving conditions for developing juvenile salmonids buried in the streambed during the winter and early spring. The forests that carpet this region stabilize streambanks, cool streams through shading, and provide large woody debris, which creates pools and complex instream habitat needed by both juvenile and adult salmonids. Hood Canal is host to a complex network of mudflats, dendritic tidal channels, lagoons, salt marshes, eelgrass beds, and sandy beaches that provide estuarine habitat for both juvenile and adult salmonids as well as the prey they depend upon.

Salmonid Species Present

Four species of Pacific Salmon and two species of trout are present within the report area. Salmon species include summer and fall chum *(Oncorhynchus keta)*, coho *(O. kisutch)*, fall chinook *(O. tshawytscha)*, and pink *(O. gorbuscha)*. Winter steelhead *(O. mykiss)*, and coastal cutthroat *(O. clarki clarki)* are the two trout species present. Each of these species employs a slightly different life history to make maximum use of available habitat, while minimizing habitat competition between the species. All of the salmonids discussed in this report display some degree of anadromy, reproducing in freshwater and growing and maturing in saltwater. All of the Pacific Salmon reproduce in freshwater and migrate to sea. Steelhead and coastal cutthroat display varying degrees of anadromous behavior. Some steelhead residualize and spend their entire life in freshwater (referred to as rainbow trout). Similarly, some coastal cutthroat trout make short forays to saltwater, but many cutthroat don't migrate to sea at all. Resident coastal cutthroat are the most widely distributed salmonid within the report area. They are present in nearly every fish-bearing stream reach, particularly above barriers to anadromous migration. All four of the salmon species present spawn during the fall and early winter months, while steelhead and cutthroat are spring spawners. The life histories employed by these salmonids place them in some portion of the freshwater and marine environments within the report area throughout the calendar year. Although an anadromous life history allows salmonids to exploit both freshwater and marine habitats, it also makes them vulnerable to human-alterations in both of these environments.

Salmonid Stock Status

Summer Chum Salmon

For management purposes, Hood Canal summer chum are divided into the Hood Canal and Union River stocks. As a whole, escapements of Hood Canal summer chum have declined to critically low levels. The escapement goal was met only three times from 1968 to 1991. Hood Canal summer chum are not directly targeted in fisheries, although they are caught incidentally in Canada, the Strait of Juan de Fuca, northern Puget Sound, and terminal areas of Hood Canal (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The National Marine Fisheries Service listed Hood Canal summer chum salmon as a threatened species under the Endangered Species Act in March 1999 (National Marine Fisheries Service 1999a, Ames *et al.* 2000). Summer chum were historically present in Big Beef Creek, Anderson Creek, the Dewatto River, and the Tahuya River. These stocks are now extinct. In contrast, the Union River supports a "healthy" summer chum stock (Washington Department of Fish and Wildlife 2003). A large and relatively intact estuary at the mouth of the Union River and releases of cold water from the Union River Reservoir during the late summer months likely aid summer chum production in this watershed (TAG 2003).

Fall Chum Salmon

Fall chum spawning in streams on the east shore of Hood Canal are classified in three stocks: Northeast Hood Canal fall chum, Dewatto fall chum, and Southeast Hood Canal fall chum. Substantial hatchery supplementation has taken place in streams on the east shore of the Canal. All three of these stocks are considered composites of hatchery and wild fish. Hood Canal fall chum are harvested in many commercial and recreational fisheries ranging from Vancouver Island to the terminal area in Hood Canal. Fairly large numbers of fall chum are present in all Hood Canal streams. The status of all three of these stocks was rated "healthy"(Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994, Washington Department of Fish and Wildlife 2003).

Coho Salmon

Coho spawning in this region are divided into three stocks: Northeast Hood Canal coho, Dewatto coho, and Southeast Hood Canal coho. Substantial numbers of hatchery-origin coho have been released into Hood Canal. The effects of these plants on wild salmon are unknown. All Hood Canal coho stocks are characterized as composites of native and non-native stocks because of the hatchery operations on the Canal. Stocks are identified based on geographic separation. The status of all three of these stocks was rated "depressed" in the early 1990s (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). However, escapements improved substantially in the following decade, resulting in an upgrade to "healthy" status in 2002 (Washington Department of Fish and Wildlife 2003).

Fall Chinook Salmon

A small number of chinook spawn in the Union and Tahuya Rivers. Chinook enhancement programs operated by the WDFW, USFWS, and the tribes have influenced the genetic integrity of Hood Canal chinook populations. Hood Canal chinook have been combined as one aggregate stock because of interbreeding of hatchery and wild fish (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The primary management objective for Hood Canal chinook is attainment of hatchery escapement goals, resulting in a high harvest rate of wild chinook commingled with hatchery chinook. From the late 1960s to the early 1990s, naturally spawning Hood Canal chinook have generally not met escapement goals. Returns to southeast Hood Canal streams, primarily the Dewatto, Tahuya, and Union Rivers, were below the escapement goal of 400 spawners (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update did not discuss chinook salmon status in watersheds included in this report.

Pink Salmon

Small numbers of pink salmon are present in west WRIA 15. Stock status of these runs was not discussed in Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes (1994) or Washington Department of Fish and Wildlife (2003).

Winter Steelhead Trout

Winter steelhead are present throughout this region, but the Dewatto, Tahuya, and Union Rivers are the main production areas. Low summer flows are the primary natural limiting factor of winter steelhead in these watersheds. Winter steelhead smolts have been stocked in the Dewatto and Tahuya Rivers and nearby streams, but the effects on native steelhead populations are unknown (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The stock status of winter steelhead in the Dewatto, Tahuya, and Union Rivers was characterized as "depressed" in the early 1990s and 2002 (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994, Washington Department of Fish and Wildlife 2003).

Coastal Cutthroat Trout

Both anadromous and resident coastal cutthroat are present in the East Hood Canal stock complex. The year 2000 SaSI Coastal Cutthroat Trout report characterized the stock status of East Hood Canal coastal cutthroat as "unknown." Long-term monitoring information was insufficient to assess the stock status (Blakley *et al.* 2000).

Effects of Land Use on Salmonid Habitat Conditions

Riverine Habitat

The east and south shores of Hood Canal are drained by numerous streams. Euro-American settlement of the Hood Canal region necessitated development of a transportation system. Numerous road crossings of streams were necessary to implement an effective road system. In some cases, little consideration was given to maintaining anadromous fish passage at road crossings, while in other cases, changes in stream character created a barrier at a once passable road crossing. Fish passage barriers are widely distributed throughout the report area, particularly on small independent tributaries.

Floodplains are often times attractive areas for agricultural or residential settlement because of their fertile soil and flat slope. Development on floodplains has resulted in conflicts between protecting property and infrastructure from flood damage, and maintaining natural floodplain functions. With the exception of large streams such as the Dewatto, Tahuya, and Union Rivers, floodplain habitat is generally present along only a small portion of the lower reaches of streams. Floodplain habitat has been impacted to some extent throughout the report area. Roads adjacent to the Hood Canal shoreline, particularly State Route 106 and Northshore Road have significantly altered floodplain habitat at the mouths of streams.

Timber harvest, agriculture, and residential and commercial development have substantially altered salmonid habitat throughout west WRIA 15 and north WRIA 14. Logging of oldgrowth forests began in the mid-1800s, with timber cut at a voracious pace. By the 1930s-1940s, entire watersheds had been denuded by logging and out-of-control wild fires. Historic logging practices included removal of trees within the riparian zone and removal of large woody debris (LWD) from streams to ease transport of logs (Amato 1996). Logging of riparian timber would have severely reduced or eliminated recruitment of LWD, reduced shade needed to maintain cool stream temperatures, and left streams susceptible to soil erosion from the surrounding uplands. Removal of LWD would have reduced pool abundance, size, and quality, and destabilized streambeds, leading to loss of spawning substrate. After the original logging was completed in the early 1900s, many stream channels were left clogged with logging slash, potentially obstructing fish passage. In 1951, the Washington Department of Fisheries created the Stream Improvement Division (SID) to correct this situation. The SID conducted extensive stream cleanout projects in Hood Canal streams until 1970. Private citizens also conducted woody debris removal and channel modification projects (Amato 1996).

Fortunately, watersheds throughout the basin have recovered from much of the damage caused by the original logging operations and stream cleaning efforts. Second growth forests now cover the majority of the area. These forests sustain the commercial forest products industry, which remains the dominant land use within the report area. Fine sediment is a limiting factor in only a small portion of the basin, particularly in the northern portion of the Port Gamble Subbasin. Large woody debris is lacking in many watersheds, particularly so in the Port Gamble and Big Beef-Anderson Subbasins. Woody debris levels are moderate to high in the Tahuya-Dewatto, Union-Mission, and North WRIA 14 Subbasins. Pool habitat is limited in many watersheds, particularly in watersheds with low LWD abundance. Streambanks are generally stable in the majority of watersheds assessed.

Roads intercept precipitation, leading to increased stormwater runoff and erosion. Roads also have the potential to destabilize hillslopes, leading to landslides that contribute fine sediments to stream channels. A road density of three miles of road per square mile of watershed is the recognized threshold for causing significant impairment of watershed functions. Road densities exceed this level in the vast majority of watersheds within the report area. With the exception of the Stavis, Harding, Anderson, and Thomas Creek Watersheds, mass wasting is not a significant problem.

Historic logging, residential development, agriculture, and the transportation network have all contributed to degradation of riparian habitat conditions in west WRIA 15 and north WRIA 14. Although reduction of riparian stand age and modification of stand composition (coniferous-deciduous ratios) have been widespread, riparian buffers are moderately functional throughout the basin. Water temperature data were sparse throughout the report area. Where data were present, summer water temperatures ranged from poor to good. Degraded riparian conditions, wetlands, and shallow man-made lakes all contributed to high water temperatures. With the exception of the Big Beef-Anderson Subbasin, hydrology information was lacking throughout the report area. No recent instream flow data were located for streams within the report area. Little information was available regarding anadromous salmonid escapement. This is likely the result of a combination of factors including the difficulty of monitoring escapement to a large number of small streams with limited man-power, as well as the practice of grouping salmonid species in large aggregate groups for management purposes (for example coho and fall chum are classified into three "stocks" – Northeast Hood Canal, Dewatto, and Southeast Hood Canal).

Nearshore Habitat

Hood Canal and the Olympic Mountains to the west provide striking scenery and numerous recreational opportunities that make the shoreline a popular site for residential development. Activities associated with shoreline development including filling of intertidal mudflat, salt marsh, and lagoon habitats, shoreline armoring, removal of riparian vegetation, and installation of boat ramps, docks, and piers, have altered natural shoreline processes, particularly recruitment of sediment and woody debris from eroding bluffs and sediment transport and deposition along the shoreline (TAG 2003). In many cases, productive habitats such as salt marshes, lagoons, and shallow bays have been severely altered or lost (Washington Department of Ecology 2000b, Point No Point Treaty Council 2003, Unpublished work). These habitats provide important rearing areas for juvenile salmonids and transition areas for both juvenile and adult anadromous fish. Losses of these nearshore habitats would be expected to adversely affect salmonid production (TAG 2003).

Surf smelt and sand lance, both important forage for anadromous salmonids, spawn near the high tide line on sand and gravel beaches. In order for these fish to spawn successfully, they need beaches with the appropriate size of substrate and shade provided by riparian vegetation (Penttila 2001). Juvenile salmonids migrate in shallow water along the shoreline to avoid predators found in deeper water and to forage on aquatic invertebrates that live in eelgrass beds and terrestrial invertebrates that fall off of riparian vegetation. Intertidal fill and bulkheads have affected anadromous salmonid production by: (1) reducing recruitment of sediment and large woody debris from bluffs and altering littoral drift of these materials along the shoreline, (2) physically burying forage fish spawning beds, thereby reducing the prey available to salmonids, (3) removing riparian vegetation, leading to reduced forage fish abundance and reduced forage opportunities on terrestrial invertebrates, and (4) forcing juvenile salmonids to migrate off-shore in deep water where they are susceptible to predation (Simenstad 2000).

Numerous roads and highways are located along the Hood Canal shoreline (Washington Department of Ecology 2000b). In many cases, road crossings at stream mouths have constrained stream and tidal channels. These constrictions alter tidal processes and sediment transport, and in some cases interfere with anadromous fish migration (TAG 2003). Shoreline roads have also reduced the width of riparian buffers throughout much of the report area, particularly along the east arm of the Canal (Washington Department of Ecology 2000b). Impervious surfaces associated with roads and other shoreline development have the potential to impair water quality through runoff of contaminated stormwater (TAG 2003).

Continued population growth in the Hood Canal region is inevitable. From 1970 to 2000, the population of Kitsap County increased from 100,000 to 230,000 people (Payne and Froyalde 2001). During this same time period, the population of Mason County expanded from roughly 21,000 to 49,400 residents (Wallace 2002). As the population has grown, conversion of timberlands to rural residential development has become more common (Brody 1991). The pressure to convert timberlands to rural residential land use will likely grow stronger as the population of the Kitsap Peninsula continues to expand. This development trend is likely to negatively impact both riverine and nearshore salmonid habitats. A balance between continued development and protection and/or restoration of natural riverine and nearshore habitat processes must be achieved to promote recovery of anadromous salmonid populations in west WRIA 15 and north WRIA 14 (TAG 2003).

WEST WRIA 15 AND NORTH WRIA 14 RECOMMENDATIONS

General Riverine Recommendations

The west side of the Kitsap Peninsula and the south shore of Hood Canal are popular residential development sights because they are relatively secluded from the urban areas of Bremerton, Tacoma, and Seattle while still being within a reasonable commute to these areas. The Canal and the Olympic Mountains to the west provide striking scenery and numerous recreational opportunities that enhance the attractiveness of this area. Historically this region was covered with a vast forest. Logging that began in the mid to late 1800s removed the majority of old-growth forests. Today, much of the report area is still covered by timberlands, the majority of which are privately owned. The Tahuya State Forest, Bremerton Municipal Watershed, and the Bangor Naval Station are the largest blocks of forestland owned by the public.

Conversion of privately owned forestland to rural residential land use has become increasingly common as more people settle in this area. Widespread conversion of forestland to rural residential land use has the potential to cause degradation of riverine habitat conditions. Removal of forest cover is often accompanied by installation of buildings, roads, driveways, and lawns. Rooftops and pavement are impervious to water, causing overland flow and reduced infiltration of precipitation. Lawns have less water holding capacity than forests. During the winter months, rapid stormwater runoff causes abnormally high peak stream flows, damaging salmonid habitat and human infrastructure. In the summer months, stream flows are abnormally low because of reduced aquifer recharge during the wet season.

The shorelines of streams, lakes, and wetlands are popular development sites. Unfortunately development in these areas often leads to removal of forested riparian buffers that provide shade during the summer months and large woody debris critical to maintenance of instream salmonid habitat conditions. Development along shorelines frequently leads to reduced floodplain function through installation of roads and dikes, or stream channelization. Stormwater runoff and wastewater from septic systems can pollute water with hydrocarbons, pesticides, herbicides, fertilizers, fecal matter, and other substances. While future residential development is inevitable, the TAG makes the following recommendations to protect existing habitat and minimize further degradation of riverine habitat conditions:

- Protect watershed conditions by preventing sprawling rural residential development. Encourage private forestland owners to continue timber production in a sustainable fashion that protects natural watershed functions (i.e. natural sediment production rates, natural runoff and stream flow regimes, mature riparian forests with coniferous trees, adequate large woody debris and pool abundance).

- Protect functional riparian forest buffers to provide shade to maintain cool summer stream temperatures, provide large woody debris necessary to maintain instream salmonid habitat, and filter soil and pollutants from runoff. Where feasible, replant native riparian vegetation at degraded sites.

- Protect functional floodplain habitat and where practical, restore lost floodplain habitat. Prevent further floodplain development. Decommissioning of an old forest road and construction of a new access road on the lower portion of Anderson Creek is one example of a potential floodplain restoration project.

- Protect the shorelines of lakes, ponds, and wetlands that maintain summer stream flows and provide rearing habitat for juvenile salmonids. Where practical, restore degraded shorelines.

- Maintain cool summer water temperatures and fish passage by preventing conversion of wetlands to shallow man-made lakes (for example Lake Symington and Lake Tahuya).

- Remove fish passage barriers.

- Minimize installation of impervious surfaces such as rooftops, roads, driveways, and lawns. Educate the public about the importance of minimizing impervious surfaces.

- Monitor instream flows and water quality parameters including temperature and dissolved oxygen levels throughout west WRIA 15 and north WRIA 14.

- Assess salmonid habitat conditions in the watersheds of the numerous small independent streams in the report area, particularly streams in the Port Gamble Subbasin and streams draining to the north shore (Tahuya-Dewatto and Union-Mission Subbasins) and south shore (North WRIA 14) of the east arm of Hood Canal.

General Nearshore Recommendations

The Hood Canal shoreline is a popular site for residential development. Filling of intertidal mudflat, salt marsh, and lagoon habitats, shoreline armoring, removal of riparian vegetation, and installation of boat ramps, docks, and piers, all associated with shoreline development, have altered natural shoreline processes including sediment recruitment from eroding bluffs and sediment transport and deposition along beaches. Shoreline development has also completely eliminated a substantial amount of nearshore/estuarine habitat that historically provided important forage fish spawning beaches and juvenile salmonid rearing and migration areas. Numerous roads and highways are located along the Hood Canal shoreline. In many cases, road crossings at stream mouths have constrained stream and tidal channels. These constrictions alter tidal processes and sediment transport, and in some cases interfere with anadromous fish migration. Shoreline roads have reduced the width of riparian buffers throughout much of the report area, particularly along the east arm of the Canal. While continued shoreline development is inevitable, the TAG makes the following recommendations to protect existing habitat and minimize further degradation:

- Protect existing functional nearshore habitats including: bluffs, bays, lagoons, salt marshes, spits, mudflats, and native riparian vegetation. Notable examples of each of these habitats include *(ordered from north to south)*:
  - Bluffs:
    - See eroding bluff section below.
  - Bays:
    - Gamble Bay
    - Big Beef Harbor
    - Seabeck Bay
    - Stavis Bay
    - Dewatto Bay
    - Tahuya Bay
  - Lagoons:
    - Foulweather Nature Conservancy Property
    - Lagoon 0.5 miles south of King Spit
    - Nick's Lagoon (Seabeck Bay)
    - Misery Point Lagoon
    - Lagoons between Misery Point and Stavis Bay
  - Salt Marshes:
    - Foulweather Bluff salt marsh
    - Foulweather Nature Conservancy Property
    - Small patches in the Driftwood Key Development (Coon Bay)
    - Mouth of Hawks Hole Creek
    - Point Julia
    - King Spit
    - Mouth of stream 15.0376
    - Mouth of Little Anderson Creek
    - Big Beef Harbor
    - Little Beef Harbor
    - Nick's Lagoon
    - Stavis Bay
    - Hood Point
    - Mouth of Boyce Creek
    - Tekiu Point
    - Mouth of Anderson Creek
    - Chinom Point
    - Mouth of Dewatto River
    - Mouth of Little Dewatto Creek
    - Mouth of Rendsland Creek
    - Mouth of Tahuya River
    - Lynch Cove
    - Mouth of Dalby Creek

    - Spits:
        - Foulweather Bluff salt marsh
        - Mouth of Gamble Creek
        - Misery Point
        - Stavis Bay
        - Mouth of Devereaux Creek
    - Mudflats:
        - Gamble Bay
        - Big Beef Harbor
        - Little Beef Harbor
        - Seabeck Bay
        - Stavis Bay
        - Dewatto Bay
        - Tahuya Bay
        - Lynch Cove
    - Native Riparian Vegetation:
        - Foulweather Bluff salt marsh
        - Foulweather Nature Conservancy property and shoreline immediately to the north and south
        - North shore of Stavis Bay north to Spear-Fir Lagoon
        - Community of Holly south to Bald Point

- Evaluate all road crossings along the Hood Canal shoreline to assess tidal function, sediment transport, and anadromous fish migration, and where necessary, implement corrective actions to restore and/or enhance natural tidal processes, sediment transport, and anadromous fish access.

- Allow eroding bluffs to function naturally to provide the sediment and large woody debris needed to maintain shoreline features such as beaches, spits, and lagoons, and shoreline habitat complexity. Notable eroding bluffs include:
    - Between the Foulweather Bluff salt marsh and the Foulweather Nature Conservancy property
    - Just south of Stavis Bay
    - Just south of the mouth of Boyce Creek
    - Just north of the mouth of Harding Creek

- Where practical, remove intertidal fill to restore/improve natural tidal and sediment transport processes.

- Where practical, remove shoreline armoring or replace armor with alternatives including large woody debris and riparian plantings.

- Prevent installation of intertidal fill and shoreline armoring, prevent removal of native riparian vegetation, and encourage landowners to install community boat ramps, docks, and piers rather than installing structures at each individual property.

- Encourage landowners to minimize disturbance of native riparian vegetation.

- Properly treat stormwater and wastewater to protect water quality.

- Reduce impervious surfaces and minimize the installation of additional impervious surfaces to reduce water pollution caused by stormwater runoff and reduce the impacts of high winter flows and low summer flows caused by reduced infiltration of precipitation.

- Remove unused creosoted pilings.

INTRODUCTION

How to Use This Document

This report is made available in a digital format known as portable document format (pdf). This allows anyone with a computer (regardless of platform) and free Adobe Acrobat Reader® 5.0 (or greater) software to read and print the document. If you are reading the report on your computer, you can take advantage of features commonly found on web pages. Blue underlined text appears throughout the document. These hyperlinks will take you directly to tables within the report and maps included separately on the CD-ROM. Cross-references *(within the text)* to tables and figures may also be clicked *(although they are not underlined blue text)* to take you directly to the referenced item. Definitions of some terms used in the text can be accessed by clicking this link ([def.]). The maps and report can be viewed simultaneously by manually opening a map from the CD-ROM *(located in the directory named PDF_Maps)* while you are reading the narrative. The Acrobat software also allows you to search for your topic of interest. Adobe Acrobat Reader is available at:

http://www.adobe.com/products/acrobat/readstep.html.

Salmonid Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon[def.] populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydroelectric power, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 *(later codified to RCW 77)* was a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- Directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- Directs the technical advisory group (TAG) to identify limiting factors for salmonids and to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;
- Defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon;"
- Defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydroelectric power, and harvest limiting factors are being dealt with in other forums.

Habitat and Salmonid Production in West WRIA 15 and North WRIA 14

The ecological characteristics of streams draining to the east and south shores of Hood Canal are largely the product of past glaciations. The topography of this area is relatively flat and dissected by numerous streams eroding sediments deposited and reworked by several glacial episodes. Numerous lakes and wetlands are present in depressions throughout the drainage network, providing important rearing habitat for juvenile salmonids, particularly coho salmon and cutthroat trout. The glaciers deposited large quantities of gravel that provide abundant salmonid spawning habitat in the low to moderate gradient streams draining this region. Groundwater travels freely through gravel lenses, aiding flow maintenance in streams during the dry summer months, and improving conditions for developing juvenile salmonids buried in the stream substrate during the winter and early spring.

The forests that carpet this region stabilize streambanks, cool streams through shading, and provide large woody debris, which creates pools and complex instream habitat needed by both juvenile and adult salmonids. Hood Canal is host to a complex network of mudflats, dendritic tidal channels, lagoons, salt marshes, eelgrass beds, and sandy beaches that provide estuarine habitat for both juvenile and adult salmonids as well as the prey they depend upon. While habitats in the Hood Canal region are far from pristine, many functional patches remain to support salmonid production. These areas warrant protection. Conversely, numerous habitats have been severely degraded or lost entirely. Many of the degraded areas have restoration potential, but in some cases habitats have been altered beyond the point of recovery.

The life history sections that follow are brief summaries intended to provide the reader with information that identifies both the similarities and differences in the life histories of salmonids present in west WRIA 15 and north WRIA 14. Readers interested in additional details of salmonid life histories are encouraged to read Trout and Salmon of North America, (Behnke 2002) which provides detailed biological and life history descriptions of the salmonid genera (including each of the species and subspecies) present on the North American continent and Pacific Salmon Life Histories, (Groot and Margolis 1998) which provides thorough biological and life history information for the five species of Pacific Salmon present in North America.

Chum Salmon *(Oncorhynchus keta)* Life History

Puget Sound chum typically spawn over a four to five month period from September to March. Chum enter rivers at the slightest increase in stream flow, but late in the spawning season high flows are not essential. Chum are strong swimmers, but not leapers, often reluctant to enter long span fish ladders, and are typically found below the first significant barrier on a stream. They prefer to spawn immediately above turbulent areas or in areas of groundwater upwelling. Eggs are generally buried 20 to 50 cm (~ 8 to 20 inches) deep in the substrate. Premature emergence occurs when eggs are buried less than 20 cm deep. Chum have adapted to spawn in lesser water depths and velocities than pink salmon and some of the other members of the genius *Oncorhynchus*. Late chum stocks often select spawning sites near springs above 4ºC (~ 39ºF), protecting the eggs from freezing and resulting in relatively consistent emergence timing from year to year. Intertidal spawning provides a similar benefit because the redd [def.] is warmed by marine waters during each tidal cycle. After hatching the chum alevins [def.] move downward in the gravel. The fish have an elongated body that allows them to move through the substrate better than coho, chinook, and steelhead alevins. They remain in the gravel from 6 to 25 days (Salo 1998).

Fry [def.] emerge from the gravel after about 5 months (generally from March through May), typically at night and immediately head downstream to the estuary, feeding along the way (Salo 1998). Chum fry typically make the transition from freshwater to brackish and saline water in less than 12 hours. The time required to adapt to the saline conditions increases with increased fish size and freshwater residency. Chum fry appear to prefer to make this transition within the brackish water (10-15 ‰- parts/thousand-salinity) lens. In the absence of extensive emergent wetlands and dendritic tidal channels on the delta, large influxes of freshwater likely push chum fry out into Hood Canal with the freshwater plume. Water movement along beaches in the nearshore zone may influence dispersion of chum fry away from the primary delta, particularly if fish are caught up in the freshwater plume (Simenstad 2000). Chum fry do not school as strongly as pink or sockeye fry. Schools are not compact and if left undisturbed, individuals tend to scatter. They typically feed on chironomids, mayfly larvae, caddisfly larvae, and other benthic invertebrates (Salo 1998).

Chum are second only to chinook in their dependence upon estuaries. The timing of entry to seawater is often correlated with warming of nearshore waters and the associated plankton blooms. The juveniles feed primarily on zooplankton including copepods and amphipods. The fry feed extensively over submerged tide flats. This allows them to exploit both freshwater and marine food webs. Juveniles move offshore when they reach 45 to 55 mm (~ 1.8 to 2.2 inches) fork length, enabling them to feed on larger prey and avoid predators. Their prey consists of a variety of zooplankton, krill, and fish larvae (Salo 1998). Chum fry residence time in Hood Canal ranges from 4 to 32 days, with an average of 24 days (Simenstad 2000). Chum mature in the Gulf of Alaska and Bering Sea before returning to spawn as three to five-year-olds. Three and four-year-olds make up the bulk of runs in South Puget Sound streams (Salo 1998).

Coho Salmon *(Oncorhynchus kisutch)* Life History

Adult coho begin to enter streams when water temperatures decrease and flows increase, often making short explorations into the stream and then returning to saltwater. Upstream migration typically takes place during the day and is triggered by a large increase in flow, especially when combined with a high tide. Most coho return to spawn at three years of age. They typically spend four to six months incubating, up to fifteen months rearing in freshwater, then sixteen months feeding in the ocean. Coho spawn in a variety of stream types, including small coastal streams, large rivers, and remote tributaries. They will spawn just about anywhere that suitable gravel (15 cm or smaller in diameter) is present. Sites with groundwater seepage are preferred. The redd is typically located at the head of a riffle to promote good oxygen circulation. The eggs generally hatch in 40 to 60 days depending upon temperature. The alevins initially move downward in the gravel, likely an adaptation to prevent premature emergence of individuals that hatch close to the surface of the streambed (Sandercock 1998).

Fry about 30 mm in length emerge from the gravel about two to three weeks after hatching. Emergence occurs primarily at night. Fry that emerge first are typically larger than later emerging fry. These individuals tend to make up a large proportion of the fingerling population because they are able to out-compete smaller individuals for territories and prey. Following emergence, the fry hide in the substrate during daylight hours. After a few days they begin to swim along the banks and use whatever cover is available. Backwaters, side channels, and small streams are preferred areas, particularly in shaded areas with overhead cover. The fry may move upstream or downstream and occupy areas inaccessible to adult coho. Some coho rear in lakes, but the majority rear in streams where they establish and aggressively defend territories. They may be found in both pools and riffles, but are best adapted to pool habitat. Trout out-compete coho in riffles. The fry are active during daylight hours, defending their territories and making frequent dashes to capture prey (and foreign objects perceived as prey). They settle to the bottom during the night to rest (Sandercock 1998).

Small individuals are often harassed, chased, and nipped by the larger individuals. Complex instream habitat composed of large rocks, large woody debris, and vegetation is important to rearing coho because production is limited by the number of suitable territories present. Displaced fry often end up in less favorable habitat where they are vulnerable to predation. They may also be driven downstream clear to the estuary. Fish that enter the estuary during the first spring or summer of life do not generally survive to adulthood. Coho are visual feeders and prefer food moving in suspension or on the surface. They rarely feed on non-moving food or along the stream bottom. The juveniles usually rear in slower sections of the stream that allow them to capture prey with a minimum of effort. Small streams are the most productive coho areas because they provide more marginal slack water habitat than large streams. The midstream portion of large streams is generally unsuitable for juvenile coho, therefore any food drifting through this area is unavailable (Sandercock 1998).

Fingerlings [def.] move into off-channel habitat when fall freshets begin. Instream cover, side channels, small intermittent streams, and ponds provide shelter from winter storms that could sweep the fish out of the system. They also provide refuge from predators at a time when cold-water temperatures limit the fingerlings' swimming ability. Beaver ponds provide shelter to avoid high flows during winter and low flows in the summer. However, small coho in ponds are more susceptible to predation from cutthroat trout. When juvenile coho rear in conditions with moderate water temperatures and abundant prey, they grow rapidly. The fry are about 30 mm long at emergence in March. They grow to 60 to 70 mm by September. By March of the second year, the fingerlings are 80 to 95 mm long. The juveniles are about 100 to 130 mm in length by May when they smolt. Exposure to water temperatures of 25ºC (77ºF) or greater is fatal to juvenile coho (Sandercock 1998).

In freshwater, juveniles are subject to predation by numerous animals including: cutthroat and rainbow trout, char, whitefish, sculpins, fish ducks, herons, mink, and otter. Garter snakes, dippers (water ouzel), robins, and crows are also significant consumers of juvenile coho. Coho smolts [def.] begin to migrate downstream in the spring. Fish size, stream flows, water temperature, dissolved oxygen levels, photo-period, and forage availability have all been identified as factors that trigger migration (Shapovalov and Taft 1954). The outmigration generally peaks in May, with most movement occurring at night. The fish grow rapidly in the nearshore waters of the estuary feeding on invertebrates. After attaining a larger size, they shift to feeding on fish, krill, and crab larvae (Sandercock 1998).

Fall Chinook Salmon *(Oncorhynchus tshawytscha)* Life History

Ocean type (fall) chinook typically migrate to sea during the first year of life, normally within three months of emergence. They spend the majority of their life in coastal waters and return to the natal stream in the fall a few days or weeks prior to spawning. In contrast, stream type (spring) chinook rear for one or more years in fresh water prior to migrating to sea where they undertake extensive ocean migrations. They return to the natal stream in the spring or summer, several months prior to spawning (Healey 1998).

Although chinook are generally considered to prefer deeper and faster spawning areas than other species in the genus *Oncorhynchus*, measurements recorded in the literature do not suggest that chinook avoid shallow water and low flows. Their large body size may allow them to hold position in faster currents and displace larger spawning substrates than other Pacific salmon, hence the perceived preference for deeper and faster water. Chinook have been observed spawning in water ranging from ~ 2 inches (5 centimeters) to 15 feet (~ 4.6 meters) deep. They appear to select spawning sites with high subgravel flows. This preference may be related to the increased sensitivity of chinook eggs to fluctuations in dissolved oxygen levels when compared to other species of Pacific salmon (chinook produce the largest eggs, yielding a small surface-to-volume ratio) (Healey 1998).

Chinook fry appear to have more difficulty emerging from small substrate than large substrate. Most fry emergence occurs at night. Following emergence the fry move downstream, also principally at night. The fry may continue the downstream migration to the estuary, or take up residence in the stream for a few weeks to a year or more depending upon the life history strategy. Fry migrants typically range in size from 30 to 45 mm fork length. Fingerling migrants are larger, with a range of 50 to 120 mm fork length. While rearing in fresh water, chinook feed primarily on larval and adult insects and zooplankton (Healey 1998).

Chinook fry feed in estuarine nearshore areas until they reach about 70 mm fork length, at which time they disperse to marine areas. Chinook rearing in estuarine areas are opportunistic feeders and will consume a variety of prey ranging from chironomid larvae and zooplankton to mysids (opossum shrimps) and juvenile fish. Most fall chinook do not migrate more than 1,000 km (about 620 miles) from their home stream during their ocean residence. Fish, particularly herring and sand lance, are the primary prey of chinook during their ocean growth phase. However, invertebrates including euphausiids (krill), squid, and crab larvae are also important at times (Healey 1998).

Pink Salmon *(Oncorhynchus gorbuscha)* Life History

Pink salmon are the most abundant species of Pacific salmon both in terms of weight and number caught by commercial fleets. Following emergence fry emigrate quickly to sea and grow rapidly while they make extensive feeding migrations. They spend about 1.5 years in the ocean prior to returning to the natal stream to spawn. Pink salmon are unique among Pacific salmon in terms of their fixed two-year life span, their small adult size (about 4.5 pounds on average), the near immediate emigration of fry to sea following emergence, and the pronounced hump that develops on the back of spawning males. The fixed two-year life span causes reproductive isolation between even and odd year runs in the same river system. This results in two genetically distinct runs. Pink salmon generally make less extensive freshwater spawning migrations than other Pacific salmon, and a large portion of spawning occurs close to saltwater. Significant amounts of intertidal spawning occur in some streams (Heard 1998).

Puget Sound pink salmon run only in odd-numbered years. Transplants of even-year pink salmon occurred in Puget Sound from 1948 to 1956. Only about 100 to 500 adult fish returned from each brood. The program was discontinued after the 1958-brood fingerlings released at Finch Creek on Hood Canal produced only a few adults in 1960. Prior to 1953, Finch Creek did not have an odd-year run of pinks similar to nearby streams. A 1953 introduction of odd-year pinks produced 1,958 adults in 1955. This formed the basis for the odd-year run currently present in Finch Creek and the Hoodsport Hatchery (Heard 1998).

In Washington, adult pink salmon begin to congregate in bays and estuaries in late August and early September. Most spawning occurs in September and October. Pink salmon generally spawn in coarse gravel with some cobbles, a large amount of sand, and a small amount of silt. Water at the spawning site is typically 30 to 100 cm deep with a velocity of 30 to 100 cm/s. These sites often coincide with increased gradient. The higher gradient likely increases water flow through the gravel, thus increasing intragravel dissolved oxygen levels. Spawning in these sites may reduce competition with spawning chum salmon which typically select redd sites associated with upwelling groundwater with little regard to the characteristics of surface water. Pink and chum salmon often spawn in close proximity to each other and are able to naturally crossbreed, but the frequency of hybridization is presumed to be low. Pink salmon excavate about one-third to one-half of the volume of material disturbed by spawning sockeye, chum, or coho salmon. Redds are typically about 1 square meter in area. The eggs are typically buried

15 to 50 cm (mean 20 to 30 cm) below the substrate surface, usually with two egg pockets per redd. Pink salmon eggs typically incubate for 100 to 120 days before hatching (Heard 1998).

Fry emergence from the gravel generally occurs 200 to 220 days after egg deposition. Most fry emergence occurs under cover of darkness, presumably to minimize predation. Newly emerged pink salmon fry have a greenish coloration on the back, silvery sides and belly, and no parr marks or pigmented spots. The fry travel at the water surface and migrate quickly downstream to saltwater. When pink fry arrive at the estuary, they are typically 28 to 35 mm in fork length. Because of the rapid migration from freshwater to saltwater, pink salmon fry feed less in freshwater than other Pacific salmon. During their early days in the marine environment, pink fry travel in schools of tens to hundreds of thousands of fish, typically moving along shorelines. During the first few weeks in saltwater, the fry spend a large amount of time in water only a few centimeters deep. Pink fry often commingle with chum fry during this period. The fry feed primarily during daylight hours on a variety of copepods. Like other juvenile salmonids, they are opportunistic, also feeding on barnacle nauplii, mysids, amphipods, euphausiids, decapod larvae, insects, larvaceans, eggs of invertebrates and fishes, and fish larvae. Once pink salmon fry reach 4.5 to 7.0 cm fork length, they transition from the nearshore environment to offshore areas. Pink salmon from Puget Sound migrate north along the coasts of British Columbia and southeast Alaska en-route to feeding areas in the northeast Pacific Ocean. British Columbia and Washington pink salmon often make lengthy migrations along the coastline of North America on the return journey to their home streams (Heard 1998).

Winter Steelhead Trout *(Oncorhynchus mykiss)* Life History

Adult winter steelhead generally enter freshwater from November through March. Spawning usually takes place within four months of freshwater entry. The majority of returning adult steelhead are three to four years of age. These fish typically display three distinct life histories: (1) two years in freshwater and one year at sea (about 50%), (2) two years in freshwater and two years in saltwater (about 30%), and (3) three years in freshwater and one year at sea (about 10%). Survival of steelhead to first spawning improves with increased juvenile size at outmigration, hence the prevalence of two or three years of freshwater rearing in the three major life histories. Small groups of adult steelhead enter the stream as water levels rise following storms. The fish generally migrate upstream during daylight hours. Spawning sites are typically located near the head of a riffle (pool tailout). The redd is constructed in medium to small size gravel and is composed of several egg pockets or "pits." Each pit is typically four inches to one foot deep and about 15 inches in diameter. After egg deposition and fertilization the female covers the pit by moving upstream a few feet and excavating another pit. In the process, the disturbed gravel is washed downstream, covering the prior excavation. The completed redd is about 60 square feet in size (Shapovalov and Taft 1954).

Resident rainbow trout (and cutthroat trout, see below) often congregate near spawning steelhead. These fish are commonly thought to be feeding on dislodged eggs, but the majority are sexually mature males that are likely attempting to participate in the spawning act similar to immature (jack) Pacific salmon. Resident rainbow trout males have been observed spawning with female steelhead in the absence of a male steelhead (Shapovalov and Taft 1954). This behavior may be an important life history strategy that is likely less common today than it was historically (McMillan 2001). Cutthroat trout also readily interbreed with steelhead (e.g. Anon 1921, Hawkins 1997, Johnson *et al.* 1999).

Unlike Pacific salmon, not all steelhead die following spawning. Some spawned-out steelhead called "kelts" migrate downstream and return to the ocean. These fish are able to mature and spawn again. Steelhead eggs incubate for 19 to 80 days depending upon water temperature (60ºF and 40ºF respectively) and in the absence of high substrate embeddedness are believed to have a hatching success of 80 to 90%. The alevins are about 18 mm in length. Fry 23 to 26 mm in length typically emerge from the gravel two to three weeks after hatching. The fry initially congregate in schools, but eventually disperse up and down the stream, with each individual staking out a territory (similar to coho). By late summer, juvenile steelhead have moved to the swifter portions of the stream. During the fall and winter months, they take shelter in backwaters and eddies to prevent being swept downstream in floodwaters. Larval insects are the principal forage of fry and fingerling steelhead. As the juveniles grow, they consume larger prey including fish. Dislodged salmonid eggs are also important food items during the late fall and winter months (Shapovalov and Taft 1954).

Juvenile steelhead have a diverse suite of life histories, with fish migrating downstream from young-of-the-year (YOY) to four years of age. The bulk of downstream migration takes place in the spring and summer. Young-of-the-year through age two juveniles make up the bulk of downstream migrants with age three and four fish only a small proportion of the outmigration. The typical life history involves migration to the ocean at two years of age, but environmental conditions and sexual development can cause changes in the behavior pattern. Age one and YOY juveniles often remain in the lower portion of the stream or estuary for an additional year prior to migrating to the ocean. Age two and older fish typically migrate to the ocean immediately. The saltwater feeding habits of steelhead are likely similar to coho, with small fish feeding on invertebrates and larger fish feeding on fish (Shapovalov and Taft 1954).

Coastal Cutthroat Trout *(Oncorhynchus clarki clarki)* Life History

Coastal cutthroat spawn from late winter through late spring in low gradient reaches of small tributary streams or the lower reaches of larger streams. These streams are typically small with summer low flows often between 0.1 m^3/s and 0.3 m^3/s (~ 3.5 to 10.6 cfs) (Johnston 1982, cited in Trotter 1997). Pea to walnut size gravel is the preferred spawning substrate. Redds are typically constructed in pool tailouts 15 to 45 cm (~ 6 to 18 inches) deep. The deep water of the pool may be used as escape cover. If larger salmonids such as coho are present, cutthroat will migrate upstream above the reaches used by salmon. Repeat spawning female coastal cutthroat produce more eggs of a larger size than first-spawning females. The larger eggs develop into larger alevins that have higher survival than small alevins. Emergence from the gravel typically peaks in mid-April, but may extend from March through June. Newly emerged fry are about 25 mm (~ 1 inch) long. The juveniles spend their first few weeks in lateral habitats including low-velocity backwaters, side channels, and other areas of cover along the channel margin (Trotter 1997).

During the summer months, young-of-the-year (Age-0) cutthroat prefer to rear in pools and other slow-water habitats. However, if coho juveniles are present, cutthroat are often displaced into riffles. Coho emerge earlier and at a larger size than cutthroat. They are able to out-compete cutthroat because of their larger size, aggressive behavior, and body morphology better adapted to pool habitat. Juvenile steelhead may displace juvenile cutthroat from riffles in a similar fashion. Steelhead are more aggressive with a body better adapted to riffle habitat than cutthroat. Interactions between young-of-the-year coho, steelhead, and cutthroat during the summer rearing period may set a natural limit on cutthroat production in streams where all three species are present. Stream-rearing juvenile coastal cutthroat may be feeding generalists, consuming whatever prey is available. Age-0 cutthroat consume both benthic (bottom dwelling) and drift organisms. Age-1 and older cutthroat often eat coho fry up to 50 to 60 mm (~ 2 inches). Cutthroat parr, smolts, and kelts (spawned adults) eat a variety of items including: insect larvae, sand shrimp, and small fish. Territoriality and agonistic behavior between juvenile salmonids decreases with the approach of winter. The juveniles over winter in deep pools associated with large woody debris and undercut banks, as well as boulders and cobbles that provide interstitial cover. Off-channel pools, side channels, and lakes are also used where available (Trotter 1997).

Puget Sound coastal cutthroat typically smolt at age 2 with an average length of 160 mm (~ 6 inches). Seaward migration begins as early as March and continues through mid-July, with a peak in late May to early June. Anadromy is not well developed in coastal cutthroat trout. They spend little time in saltwater and often remain in the tidewater and estuarine reaches of their home streams. While in saltwater, cutthroat generally travel along the shoreline within 50 km (~ 31 miles) of the home stream and are reluctant to cross deep open water. They grow about 25 mm (~ 1 inch) per month while foraging in salt water. Marine survival of coastal cutthroat is as much as 40% higher than other Pacific salmonids. Predation by Pacific hake, spiny dogfish, harbor seals, and adult salmon likely accounts for the majority of mortality (Trotter 1997).

Coastal cutthroat seldom over winter in salt water. They often return to freshwater the same year they migrated to sea, but not all of these fish are spawners. Few female coastal cutthroat mature sexually before age 4. The immature fish over winter in freshwater then return to saltwater a second time to forage. These fish spawn following their second return to freshwater (Trotter 1997). In Puget Sound only 20 to 27% of first-return females spawned, while nearly all of the first-return males spawned (Johnston 1982, cited in Trotter 1997). In large streams (summer low flows > 1.4 m^3/s, ~ 49 cfs) fish enter freshwater from July through November with a peak in September and October. In small streams (summer low flows < 0.6 m^3/s, ~ 21 cfs) that flow directly to saltwater, cutthroat enter freshwater from December through March with a peak in December and January.

Coastal cutthroat survive spawning quite well (Trotter 1997). Kelts return to saltwater from late March through early April, about one month earlier than cutthroat smolt outmigration. This timing places the adults in position to feed on outmigrating juvenile salmonids, particularly pink and chum salmon (Trotter 1997).

BASIN HISTORY

Native American History

When white settlers arrived on Hood Canal in the mid-1850s, a group of native village communities inhabited the Hood Canal region. These people called themselves tuwa'duxq, which was anglicized to Twana (Elmendorf and Kroeber 1992). This group of communities was not united politically, but they did speak the same language, practiced common customs, and shared a single territory. Each community had a plank-house village that was shared by all community members during the winter months. Originally there were nine Twana-speaking winter-village communities: Dabop, Quilcene, Dosewallips, Duckabush, Hoodsport, Skokomish, Vance Creek, Tahuya, and Duhlelap. The Skokomish are the only remnant of this culture (Elmendorf and Kroeber 1992).

Euro-American Settlement & Logging

Euro-Americans began settling the Hood Canal region in the 1850s. Logging provided the initial motivation for settlement. The Pope & Talbot Company constructed the first mill on Hood Canal in 1853 at Port Gamble (Amato 1996). During the first year of operation in 1854, the mill produced nearly 3.7 million board feet of lumber, 64,000 shingles, and 223 masts and spars. By 1858, the Port Gamble Mill was capable of producing 50,000 board feet of lumber per day, and had become the largest lumber manufacturer in Puget Sound. In 1857, the Washington Mill Company constructed a mill at Seabeck. The mill's initial production capacity was 15,000 board feet of lumber, but by 1864, output had increased to 50,000 board feet per day. In 1874, the mill's annual production was 14 million board feet of lumber (Amato 1996).

In the early days, timber was readily accessible from the shoreline of the Canal. Fifty logging camps were located on the shores of Hood Canal by the late 1850s. From 1865 to 1885, timber from the shores of the Canal was the sole source of raw logs for the large mills at Seabeck, Port Gamble, and Port Ludlow. The early logging methods employed a team of six to ten men and a team of eight to ten oxen. The trees were felled by hand with a jackscrew, peavey, borer, and single bit axe. The crude tools and immense size of the trees made for slow work, often requiring an entire day to fell one tree. Double-bitted axes and two-man crosscut saws increased the pace of cutting, but the work was still labor intensive (Amato 1996).

High-grade logging was the typical practice. Trees were not cut unless they would produce at least three logs twenty-four feet long and thirty inches in diameter. The trees had such large butt swells that they were cut a minimum of twelve feet (often twenty feet) up from the base. The top forty to fifty feet were typically considered too slender to be valuable, so this portion of the tree was also left in the woods. Logging was initially concentrated close to rivers and shorelines *(i.e. riparian areas)* to ease log transport. The trees were either felled directly into the water or logs were dragged with a team of oxen. The logs were then floated downstream to the mouth of the stream where they were secured in a log boom and pulled to mills with a steam tugboat. Splash dams were commonly used on Washington Coastal streams (Wendler and Deschamps 1955, cited in Amato 1996), but this practice was apparently not widely used in the Hood Canal region. The only known splash dam was located on the Dosewallips River (Washington Department of Fisheries 1932, cited in Amato 1996).

The majority of oldgrowth within two miles of the Hood Canal shoreline had been logged by the early 1880s (Buchanan 1936, cited in Amato 1996). Once timber supplies along the shorelines were exhausted, logging moved further inland. Steam donkeys and railroads replaced oxen teams. Clearcut logging followed by burning was the common harvest practice in the late 1800s. Accidental logging-related fires were frequent occurrences and in severe cases, entire watersheds were laid to waste. The Union River Logging Company constructed the first railroad in 1883 at Clifton. Most railroad grades were constructed along the valley floors. Cinders from the steam locomotives frequently caused fires and damaged substantial acreages of timber. Often times, trees cut on the side of the river opposite the railroad grade were yarded across the stream, resulting in large accumulations of logging slash in the channel (Amato 1996).

The Union River was too narrow and shallow to float logs downstream, so a railroad was built from the mouth upstream four miles in 1882. The railroad was eventually extended five additional miles. The railroad logging operation was discontinued in 1912, likely because of exhaustion of the timber supply. The final large-scale railroad logging enterprise began in 1920 when the West Fork Logging Company established Camp Union in the upper Big Beef Creek Watershed, near present day Lake Symington. The operation employed over 650 men, nearly 100 miles of railroad track, and four locomotives (Amato 1996). The operation cut 1.5 million board feet of timber per day at peak operation. Much of this timber was cut in the headwaters of Big Beef, Seabeck, Stavis, and Anderson Creeks. The Charles R. McCormick Logging Company purchased the West Fork Logging Company in 1927. By 1932, the company had cut 345 million board feet of timber and estimated that 385 million board feet remained to be cut. The entire Big Beef Creek Watershed upstream from RM 5.0 had been completely logged. The company abandoned Camp Union in 1936 after exhausting the timber supply. The Pope & Talbot Company established Camp Gamble on the east shore of Port Gamble Bay in the early 1920s. The camp was the base of operations for logging the remaining oldgrowth timber on the northern Kitsap Peninsula (Amato 1996).

Truck logging began to replace railroad logging around the 1930s. Trucks could reach timber stands on ground too steep for railroad grades. The upper portions of many Hood Canal Watersheds were soon marked with a growing network of hastily constructed logging roads. The log truck enabled fast and efficient cutting of most of the remaining oldgrowth stands in the Hood Canal region (Amato 1996). The majority of oldgrowth in the southwest portion of WRIA 15 was cut between 1915 and 1930. The main logging camp of the Stimson Lumber Company was located along Stimson Creek. The company cut timber in the Dewatto River, Tahuya River, and Stimson Creek watersheds around 1914. The company had a log dump on Stimson Creek and a railroad near the present site of Elfendahl Pass Road. The company abandoned its holdings in 1931 when the timber supply was exhausted (Amato 1996). With the exception of a three-quarter mile stretch at the mouth, the entire Big Mission Creek Watershed had been logged by the early 1930s. The upper Dewatto River Watershed had been completely logged and burned. Most of the Rendsland Creek Watershed had consisted of cedar swamp, but the area was so thoroughly logged that only stumps and bare soil remained (Washington Department of Fisheries 1932, cited in Amato 1996).

Woody Debris Removal

Woody debris has been removed from Pacific Northwest streams for at least 150 years (Sedell and Luchessa 1982). The first debris removal was associated with log drives. Prior to floating logs downstream, sunken logs, woody debris, leaning trees, large boulders, and other potential obstacles were cleared from the channel by blasting or hauling (Brown 1936, Amato 1996). Once logging activity was completed, a clear channel was no longer necessary, so logging slash and other waste were often left in the channel. By the 1930s, large accumulations of logging slash were present in many Hood Canal streams (Washington Department of Fisheries 1932, cited in Amato 1996). The Washington Department of Fisheries Stream Improvement Division (SID) was created in 1951 because of concerns that logging slash was an impediment to migrating salmon. The SID worked for twenty years to remove LWD, beaver dams, and other instream structures believed to be barriers to upstream salmon migration (Jenks *et al.* 1992, cited in Amato 1996). Big Beef, Anderson, Rendsland, Stimson, Shoofly, and Big Mission Creeks, as well as the Dewatto, Tahuya, and Union Rivers were all modified by the SID between 1955 and 1970 (Amato 1996).

Beaver Removal

Beaver trapping in Puget Sound began in 1833 with the establishment of Fort Nisqually, a Hudson's Bay Company trading post. Beaver dams were removed by loggers to facilitate log drives, private citizens to prevent flooding, and the WDF SID to enhance fish passage (Amato 1996). Today, North American beaver populations are increasing rapidly because of a relative absence of predators, regulation of trapping, and abundant forage and habitat, but the present populations likely represent only a small fraction of historic numbers (Naiman *et al.* 1988).

Recent Land Development

Residential and commercial development grew rapidly in many parts of the Hood Canal region from 1980 to 1995 (Amato 1996). From 1980 to 1990, housing units grew 29% in west Kitsap County. Belfair is the fastest growing community on Hood Canal, with an annual growth rate near 10% in the 1980s (Rothgeb 1991). As of 1991, the only sewage treatment plants on Hood Canal were located at Port Gamble and the Alderbrook Inn near Union. All other sewage discharges to septic systems, many of which are old and failing (Brody 1991). Failing septic systems and poor livestock management have caused water quality violations on many Hood Canal streams (Puget Sound Cooperative River Basin Team 1991, 1993). From 1970 to 2000, the population of Kitsap County increased from

100,000 to 230,000 people (Payne and Froyalde 2001). During this same time period, the population of Mason County expanded from roughly 21,000 to 49,400 residents (Wallace 2002). As the population has grown, conversion of timberlands to rural residential development has become more common (Brody 1991). The pressure to convert timberlands to rural residential land use will likely grow stronger as the population of the Kitsap Peninsula continues to expand. This development trend is likely to negatively impact both riverine and nearshore-estuarine salmonid habitats (TAG 2003).

BASIN DESCRIPTION

West WRIA 15

West Water Resource Inventory Area (WRIA) 15 extends from Foulweather Bluff at the mouth of Hood Canal southward along the shoreline to the terminus of the east arm of Hood Canal. The eastern boundary extends to the headwaters of all streams draining to the east shore of Hood Canal. The basin covers about 290 square miles of the Kitsap Peninsula. The west Kitsap Basin has been divided into four subbasins for purposes of organizing this report. The Port Gamble Subbasin is the northern most subbasin and extends from Foulweather Bluff south to the community of Olympic View. The Big Beef-Anderson Subbasin begins near Olympic View and extends south to the community of Holly. The Tahuya-Dewatto Subbasin extends from Holly south and east to the eastern edge of the Tahuya River Watershed. The Union-Mission Subbasin encompasses the watersheds east of the Tahuya River Watershed and south of the Union River within WRIA 15. See Maps 1 and 2. Specific descriptions of each subbasin and watershed are located in the Habitat Limiting Factors chapters.

North WRIA 14

North WRIA 14 covers about 22.5 square miles and includes all WRIA 14 streams that drain to the south shore of Hood Canal. The majority of streams in this area are 0.5 to 2 miles in length. See Map 2. Specific descriptions of each watershed within this subbasin are located in the North WRIA 14 Habitat Limiting Factors chapter.

Geology

The bedrock of the Kitsap Peninsula is composed of thick beds of basaltic and andesitic lavas that erupted from fissures and cones during the early and middle portions of the Eocene Epoch of the Tertiary Period. Sea level fluctuated during this period, causing some of the lavas to be deposited in marine waters. Streams eroded the volcanic rocks and deposited sediment throughout the area. These sediments form interbeds and lenses in the lava rock. Volcanic activity decreased considerably during the late Eocene. From that time through the Oligocene and early Miocene Epochs, thousands of feet of marine sedimentary rock were laid down on top of the volcanic rocks (Garling and Molenaar 1965).

During the late Pliocene Epoch, at the close of Tertiary time, a north-south uplift produced the present Cascade and Olympic Mountains. The Puget Trough was formed by a downwarp associated with building of the mountains. Sediments accumulated in the Puget Trough through the Pliocene and most of the Pleistocene Epochs. The sediments ranged in size from fine-grained clays to coarse sands and gravels. The fine sediments likely accumulated in freshwater lakes and swamps. Peat and lignite formed when plant material accumulated at the bottom of lakes and swamps. Streams draining the surrounding mountains and glaciers present during the Pleistocene deposited the coarse sediments (Garling and Molenaar 1965).

Glaciers originating in Canada traveled into the Puget Sound lowland several times during the Pleistocene Ice Age. The ice ranged in thickness from 2,000 to 5,000 feet thick. Climate fluctuations caused the ice sheets to advance and retreat repeatedly. The last glacier retreated about 14,000 years ago. Streams flowed from the front of the glaciers, carving channels and depositing sediments. Lakes formed in ice-dammed valleys, leading to deposition of silts and clays. The climate warmed long enough between glacial advances for vegetation, including forests to recolonize the area. The vegetation was buried when the glaciers returned, forming compacted peat beds. Advancing glaciers "smeared" till (cobbles mixed with silt and clay) over the area (Garling and Molenaar 1965).

Although four glaciations are believed to have occurred in the Puget Sound lowland, only two are identifiable on the Kitsap Peninsula, the Salmon Springs glaciation, and the Fraser glaciation (most recent). The Olympia interglaciation occurred in the period between the Salmon Springs and Fraser glaciations. During the Olympia interglaciation, streams draining the Cascades and Olympics reworked the glacial sediments deposited during the Salmon Springs glaciation. The streams also deposited additional sediment from the mountains, forming a floodplain. Fine silts, clays, and peats, referred to as the Kitsap Formation, were deposited in slow streams, shallow lakes, and marshes. The Colvos Sand, thick beds of sand with interbeds of gravel and clays, was laid down as the Vashon Glacier advanced during the Fraser Glaciation. The Vashon Glacier is believed to have occupied the area for a maximum of 1,500 years. The advancing ice sheet cut deeply into the underlying materials. Valleys were deepened from 300 to 900 feet below present sea level. The ice advanced as far south at the Black Hills where streams drained into the Chehalis River via valleys near Matlock and Gate. Glacial Lake Russell formed when the ice sheet retreated. Once the ice completely vacated Puget Sound, sea water entered via the Strait of Juan de Fuca and created the present marine environment of Puget Sound (Garling and Molenaar 1965).

Climate

Climate in the southern portion of west WRIA 15 and north WRIA 14 is typical of the Puget Sound trough, with mild-wet winters and warm-dry summers. The average summer temperature range is 70 to 80°F with temperatures in the winter averaging 40 to 50°F during the day and 30 to 40°F at night (Puget Sound Cooperative River Basin Team 1991). Storms passing through the gap between the Olympic Mountains and Black Hills typically deliver large amounts of precipitation to the southwest portion of the Kitsap Peninsula during the winter months (Garling and Molenaar 1965). Average precipitation varies from 90 inches on the west shore of Hood Canal at Hoodsport to 60 inches at Belfair. Precipitation patterns are characterized by frequent rainfall of low intensity, with half the annual precipitation falling during the November-January time period. Snowfall is limited by low elevations and the moderating temperature influence of Hood Canal. The higher elevations inland on the Tahuya peninsula receive more snowfall than the shoreline of Hood Canal. Predominant wind direction is from the south and southwest, allowing for a relatively long fetch which occasionally creates extreme wave action at the head of Lynch Cove (Puget Sound Cooperative River Basin Team 1991).

Climate in the northern portion of west WRIA 15 is generally mild and influenced by maritime air masses that move across the area from the Pacific Ocean. Prevailing winds are from the south and southwest in the fall and winter, switching to north and northwest in the spring and summer. The months of July and August form a well-defined dry season when the rainfall is only 5% of the annual total. Seventy-five percent of annual precipitation falls in the rainy season, October through March (Puget Sound Cooperative River Basin Team 1993). The northern portion of the Kitsap Peninsula falls within the rainshadow of the Olympic Mountains and is considerably drier than the southern peninsula (Garling and Molenaar 1965). The rainshadow and changes in elevation cause the mean annual precipitation to vary from 30 inches on the northern end of the peninsula up to 70 inches on the central peninsula. Average temperatures range from 40°F in the winter to 62°F in the summer (Puget Sound Cooperative River Basin Team 1993). See Map 12.

Hydrology

Riverine

Streams draining the east shore of Hood Canal tend to originate in lakes or wetlands. These streams are generally small with moderate gradients and exhibit low flows in the late summer and early fall (Williams *et al.* 1975). Stream flow monitoring was not conducted on the Kitsap Peninsula until 1945 (Garling and Molenaar 1965). Most stream gage data were gathered from the mid 1940s to the late 1950s (Washington Department of Natural Resources 1995). Flow regimes of individual streams are described in the Habitat Limiting Factors chapters.

Table 1. Statutory Minimum Flows for Select West WRIA 15 Streams (WAC 173-515-030).

	Instantaneous flow (cubic feet per second)																				
	Jan.-Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
Stream	All Month	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
Union River	<u>65</u>	<u>59</u>	<u>53</u>	<u>48</u>	<u>44</u>	<u>40</u>	<u>36</u>	<u>33</u>	<u>29</u>	<u>27</u>	<u>24</u>	<u>22</u>	<u>20</u>	<u>20</u>	<u>20</u>	<u>20</u>	<u>20</u>	<u>27</u>	<u>35</u>	<u>47</u>	<u>65</u>
Tahuya River	90	90	90	72	58	47	38	31	<u>25</u>	<u>18</u>	<u>12</u>	<u>8.5</u>	<u>5.5</u>	<u>5.5</u>	<u>5.5</u>	<u>7</u>	<u>13</u>	25	48	90	90
Rendsland Creek	18	18	18	18	16	13.5	12	<u>10</u>	<u>9</u>	<u>8</u>	<u>7</u>	<u>6</u>	<u>5</u>	<u>5</u>	<u>5</u>	<u>5</u>	<u>7</u>	9.5	13	18	18
Dewatto River	75	75	75	60	49	39	32	25	<u>22</u>	<u>20</u>	<u>17.5</u>	<u>15.5</u>	<u>13.5</u>	<u>13.5</u>	<u>13.5</u>	<u>13.5</u>	<u>17</u>	21	39	75	75
Anderson Creek	10.5	10.5	10.5	10.5	10	9	8.5	8	7.5	7	6.5	6	6	6	6	6.5	7	8	8.5	9.5	10.5
Stavis Creek	15	15	15	14	13	12	11	10	9.5	9	8	7.5	7	7	7	7	8.5	10.5	12.5	15	15
Big Beef Creek	40	40	40	31	24	18	<u>14</u>	<u>11</u>	<u>8.5</u>	<u>6.5</u>	<u>5</u>	<u>4</u>	<u>4</u>	<u>4</u>	<u>4.5</u>	<u>5.5</u>	<u>6</u>	<u>7</u>	12	22	40
Little Anderson Creek	8	8	8	8	6	4.5	3.5	<u>3</u>	<u>2</u>	<u>1.5</u>	<u>1.5</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1.5</u>	<u>1.5</u>	<u>2.5</u>	4.5	8	8

Source: (State of Washington 1988)
Note: Underlined text indicates closure to additional consumptive uses.

Table 2. West WRIA 15 and North WRIA 14 Streams Closed to Further Appropriations (WAC 173-515-040 & 173-514-040).

Stream	Tributary to	Closure Period
	West WRIA 15	
Mission Lake & Tributaries	Big Mission Creek	All year
Unnamed Stream and Tributaries	Hood Canal	All year
Seabeck Creek and Tributaries	Hood Canal	All year
Gamble Creek and Tributaries	Port Gamble	All year
Union River and Tributaries	Hood Canal	All year
Tahuya River and Tributaries	Hood Canal	June 15-Oct. 15
Rendsland Creek and Tributaries	Hood Canal	June 1-Oct. 15
Dewatto River and Tributaries	Hood Canal	June 15-Oct. 31
Big Beef Creek and Tributaries	Hood Canal	May 15-Oct. 31
Little Anderson Creek and Tributaries	Hood Canal	June 1-Oct. 31
Little Mission Creek and Tributaries	Hood Canal	All year
Stimson Creek and Tributaries	Hood Canal	All year
Little Shoofly Creek and Tributaries	Hood Canal	All year
Shoofly Creek and Tributaries	Hood Canal	All year
Caldervin Creek and Tributaries	Hood Canal	All year
Hall Creek and Tributaries	Hood Canal	All year
Hoddy Creek and Tributaries	Hood Canal	All year
Fay Creek and Tributaries	Hood Canal	All year
Brown Creek and Tributaries	Hood Canal	All year
West Creek (15.0444) and Tributaries	Hood Canal	All year
Harding Creek (15.0408) and Tributaries	Hood Canal	All year
Little Boston Creek (15.0350) and Tributaries	Port Gamble	All year
	North WRIA 14	
Alderbrook Creek	Hood Canal	May 1 to October 31
Twanoh Creek	Hood Canal	May 1 to October 31
Source: (State of Washington 1988)		

Estuary/Nearshore

Hood Canal is subject to weak tidal exchanges, seasonal nutrient loading, and low surface water salinity because of its unique bathymetry. Glacial sills at the entrance to the Canal reduce water exchange and deep-water circulation. Cold, nutrient-rich upwelling water from the Pacific Ocean intrudes into the Canal only in the late summer months (Yoshinaka and Ellifrit 1973). Tidal exchange in the Canal is slow. Hood Canal also has an exceptionally large freshwater lens (up to three meters in depth, approx. 10 feet) that is particularly pronounced from December through June when stream flows are high and tidal mixing is weak. The lens leads to warmer summer and colder winter temperatures than would occur if the surface water was more saline (Yoshinaka and Ellifrit 1973).

Vegetation

Large fires historically occurred at 200-year intervals in the Hood Canal region. Windstorms were a less significant disturbance than fires. Because of natural disturbances, some watersheds may have been forested with multiple timber age classes, rather than complete coverage of oldgrowth. Explorers in the late 1700s through the late 1800s described expansive coniferous forests composed of Douglas-fir, western redcedar, and western hemlock. The riparian zones of Big Beef Creek, and the Tahuya and Union Rivers were said to have large quantities of prime timber (Amato 1996). Labbe (2002) provides additional descriptions of the historic character of west Kitsap riparian forests. Dead and fallen trees were commonplace in the oldgrowth forests present historically. The fallen trees made travel difficult for the early explorers (Amato 1996). The virgin forests that originally covered the area have been more completely harvested than any other portion of the Douglas-fir region of western Washington and Oregon, largely because of the easy accessibility of the Kitsap Peninsula and close proximity to mills along Puget Sound. Coniferous and deciduous trees reseeded most of the logged or burned areas. Salal, ferns, huckleberry, Oregon grape, and rhododendron generally form a dense and tangled understory. Mosses, cranberry bushes, wire grass, reeds, sedges, rushes, and ferns are the principal vegetation in the marshy areas scattered throughout the Peninsula (Garling and Molenaar 1965). Timber production is still an important part of the Hood Canal economy. In the late 1980s, the west side of Hood Canal produced more timber than any other area of similar size in Washington, excluding Lewis and Cowlitz Counties (Brody 1991). See Map 11 for land cover.

Effects of Land Use on Salmonid Habitat Conditions

Riverine Habitat

Timber harvest, agriculture, and residential and commercial development have altered salmonid habitat both directly and indirectly. Logging of oldgrowth forests (including riparian vegetation), removal of instream woody debris, stream channel modifications (diking, channelization, and damming), filling and bank armoring, removal of beaver dams, water quality degradation, and construction of impervious surfaces have all made significant contributions to habitat modifications. The near complete removal of oldgrowth forests by commercial logging operations is the most significant ecological change to the Hood Canal ecosystem. Almost no oldgrowth forests remain on the west side of the Kitsap Peninsula (Amato 1996). Residential areas are home to 87% of the population in the southern portion of west WRIA 15, while occupying only 6.2% of the land base. There are about 713 miles of roads in southern west WRIA 15 (not including spur roads on forest lands). About 67% of these roads are surfaced with gravel and/or dirt (Puget Sound Cooperative River Basin Team 1991).

The majority of land in west WRIA 15 and north WRIA 14 is privately owned. The State of Washington owns large blocks of land in southwest WRIA 15. The Bangor Naval Reservation and the Bremerton Municipal Watershed are also significant government holdings. See Map 10. Pope Resources (a spin-off of the Pope & Talbot Company) is the largest private landowner in the Hood Canal Region with about 60,000 acres of holdings. Simpson Timber Company owns 8,000 acres. Other large timber landowners include Traveler's Insurance (4,600 acres), ANE Forest of Puget Sound (4,600 acres), G.R. Kirk Company (3,500 acres), Pacific Funding Corporation (3,000 acres), J. Hofert Company (2,000 acres), and Manke & Sons (> 1,000 acres) (Brody 1991). Historically, Hood Canal forests were dominated by Douglas-fir during early successional stages. Late successional stands were composed of a mix of Douglas-fir, western hemlock, and western redcedar. The complex oldgrowth forests have been replaced with commercial monocultures of Douglas-fir; many forests are now nearly 100% Douglas-fir. The current timber harvest management regime of cutting on a 50 to 70 year rotation precludes development of oldgrowth forest characteristics, which typically require 200 years to develop (Amato 1996).

Removal of oldgrowth riparian vegetation eliminated the primary source of large woody debris. This would have led to decreased sediment storage capacity, fewer and shallower pools, and decreased channel complexity needed as cover for rearing fish. Widespread logging of oldgrowth forests may have caused substantial increases in peak flows or frequency of channel-modifying flows because of increased snowmelt or rain-on-snow events. The increased flows may have caused increased sediment loads derived from mass wasting, surface erosion, bank erosion, or loss of in-channel storage capacity. The increased sediment loads likely led to aggradation, pool filling, substrate embeddedness, and instream habitat simplification. Floating logs down streams likely caused damage to streambeds and streambanks, especially when moving at high speed during freshets (Amato 1996).

Diking, damming, channelization, filling, and bank armoring of Hood Canal streams began with the first settlers in the 1850s. The earliest modifications were intended to keep water and logs in the main river channel during log drives. Sloughs, swamps, low meadows, and banks along wide stream reaches were blocked off. Early settlers ditched, drained, and diked floodplains and wetlands to convert the land to agricultural production (Amato 1996). Mainstem streams were dredged, channelized, and diked to prevent flooding. Side channels, and sloughs were blocked off, and small tributaries were ditched and rerouted. Banks were armored in response to erosion caused by development encroachment and removal of riparian vegetation. For example, three branches of lower Big Beef Creek were consolidated, the main channel was dredged, and a dike was built with the dredge spoils (Amato 1996). In a general sense, human activities have substantially altered the character of riverine habitat in west WRIA 15 and north WRIA 14.

Nearshore Habitat

Development along the Hood Canal shoreline has substantially altered nearshore habitat characteristics throughout west WRIA 15 and north WRIA 14 (Washington Department of Ecology 2000b, Point No Point Treaty Council 2003, Unpublished work). Activities associated with shoreline development including filling of intertidal mudflat, salt marsh, and lagoon habitats, shoreline armoring, removal of riparian vegetation, and installation of boat ramps, docks, and piers, have altered natural shoreline processes, particularly recruitment of sediment and woody debris from eroding bluffs and sediment transport and deposition along the shoreline (TAG 2003).

Intertidal mudflats, salt marshes, lagoons, and shallow bays provide critical habitat for juvenile and adult anadromous salmonids and their prey. Significant amounts of intertidal filling and shoreline armoring have altered or destroyed substantial portions of these habitats (Washington Department of Ecology 2000b, Point No Point Treaty Council 2003, Unpublished work). Two of the most notable examples of nearshore habitat modifications occur along the entire east arm of Hood Canal (Tahuya-Dewatto, Union-Mission, and north WRIA 14 Subbasins), and at the Driftwood Key development (Coon Bay) in the Port Gamble Subbasin (Hirschi *et al.* 2002, TAG 2003).

Intertidal fill and bulkheads have impacted anadromous salmonid production by: (1) reducing recruitment of sediment and large woody debris from bluffs and altering littoral drift of these materials along the shoreline, (2) physically burying forage fish spawning beds, thereby reducing the prey available to salmonids (Penttila 2001), (3) removing riparian vegetation, leading to reduced forage fish abundance and reduced forage opportunities on terrestrial invertebrates, and (4) forcing juvenile salmonids to migrate off-shore in deep water where they are susceptible to predation (Simenstad 2000).

Numerous roads and highways are located along the Hood Canal shoreline (Washington Department of Ecology 2000b). In many cases, road crossings at stream mouths have constrained stream and tidal channels. These constrictions alter tidal processes and sediment transport, and in some cases interfere with anadromous fish migration (TAG 2003). Shoreline roads have also reduced the width of riparian buffers throughout much of the report area, particularly along the east arm of the Canal (Washington Department of Ecology 2000b). Impervious surfaces associated with roads and other shoreline development have the potential to impair water quality through runoff of contaminated stormwater (TAG 2003).

SALMONID STOCK STATUS

Chum Salmon

Summer Chum

Hood Canal summer chum enter the Canal from early August through late September. Spawning takes place from late August through October, earlier than fall chum stocks spawning in the same streams. Hood Canal summer chum were divided into the Hood Canal and Union River stocks. Union River summer chum are differentiated from Hood Canal summer chum based on genetics, geographic separation of spawning grounds, and earlier spawn timing. No hatchery summer chum have been released in Hood Canal. The Union River and Hood Canal stocks are both native and depend on wild spawning for production. Hood Canal summer chum are not directly targeted in fisheries, although they are caught incidentally in Canada, the Strait of Juan de Fuca, northern Puget Sound, and terminal areas of Hood Canal. As a whole, escapements have declined to critically low levels. The escapement goal *(average of the highest historic escapements)* was met only three times from 1968 to 1991. Escapement goals are 41,200 fish in even-years, and 20,100 fish in odd-years (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994).

The majority of fish from the Hood Canal summer chum stock spawn in rivers on the west shore of Hood Canal (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). Summer chum were historically present in Big Beef Creek, Anderson Creek, the Dewatto River, and the Tahuya River. The 2002 SaSI update declared these stocks extinct (Washington Department of Fish and Wildlife 2003). Hood Canal summer chum spawn from mid-September to late October, a month earlier than Hood Canal fall chum. In 1968, the Hood Canal summer chum escapement was 43,450 fish. In 1991, the escapement was only 703 fish. Escapement had been chronically low since 1980 (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The NMFS listed Hood Canal summer chum salmon as a threatened species under the Endangered Species Act in March 1999 (National Marine Fisheries Service 1999a, Ames *et al.* 2000). Large coho, chinook, and chum hatchery programs on Hood Canal may cause increased competition and predation on summer chum. The WDFW, PNPTC, and USFWS initiated a summer chum brood stock program in 1992. Broodstock are captured in Quilcene Bay and the Big Quilcene River. The program is intended to supplement Hood Canal summer chum production.

Union River summer chum spawn from late August to early October, one to two weeks earlier than the Hood Canal summer chum. The Union River summer chum stock was characterized as “healthy.” From 1968 to 1991, escapement ranged from 40 to 2,000 fish. Abundance has increased since 1978 (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The Union River summer chum stock was rated “healthy.” From 1994 to 2001, escapement ranged from 159 to 1,500 fish. Most summer chum spawning occurs in the lower three miles of stream. The WDFW and Hood Canal Salmon Enhancement Group are conducting a hatchery supplementation program to increase Union River summer chum abundance sufficiently to support reintroduction of summer chum to the Tahuya River (Washington Department of Fish and Wildlife 2003). Because of the limited distribution of summer chum in west WRIA 15 and north WRIA 14, a separate fish distribution map was not created. The chum distribution depicted in Map 14 includes the Union River summer chum stock.

Fall Chum

Fall chum enter Hood Canal from early October through early January. Spawning commences in late October and may continue through January. Ten fall chum stocks are present in Hood Canal. The prolonged spawn timing is the result of differences in the run timing of the various stocks. Fall chum spawning in streams on the east shore of Hood Canal have been classified in three stocks: Northeast Hood Canal fall chum, Dewatto fall chum, and Southeast Hood Canal fall chum. Substantial hatchery supplementation has taken place in streams on the east shore of the Canal. Hatchery plants of fall chum were ongoing as of 1994. All three of the stocks are therefore considered composites of hatchery and wild fish. Hood Canal fall chum are harvested in many commercial and recreational fisheries ranging from Vancouver Island to the terminal area in Hood Canal. As a whole, Hood Canal fall chum met the escapement goal only twice from 1984 to 1991, but the trend from 1981 to 1991 was a slight increase. Fairly large numbers of fall chum are present in all Hood Canal streams (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994).

Northeast Hood Canal Fall Chum

Anderson, Big Beef, Seabeck, and Stavis Creeks are the main production areas of Northeast Hood Canal fall chum. Hatchery plants have likely altered the genetic composition of this stock. Therefore, it is classified as a mixed stock comprised of a composite of native and hatchery fish. Northeast Hood Canal fall chum were rated "healthy" in 1994. From 1968 to 1991, escapement ranged from 500 to 8,000 fish. The mean escapement from 1984 to 1991 was 1,800 fish (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Northeast Hood Canal fall chum "healthy." From 1992 to 2001, escapement ranged from 3,217 to 28,615 fish (Washington Department of Fish and Wildlife 2003).

Dewatto Fall Chum

Dewatto fall chum spawn in the streams that drain into Dewatto Bay and the area to the north and south. The Dewatto River and two of its tributaries, Shoe (15.0421) and White Creeks (15.0424) are the main production areas. Hatchery plants and strays have likely altered the genetic composition of the native Dewatto fall chum. The stock was accordingly classified as a mixed stock comprised of a composite of hatchery and native fish. The stock was rated "healthy" in 1994. From 1968 to 1991 escapement ranged from 300 to 4,600 fish (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Dewatto Fall Chum "healthy." From 1992 to 2001, escapement ranged from 997 to 14,233 fish (Washington Department of Fish and Wildlife 2003).

Southeast Hood Canal Fall Chum

Southeast Hood Canal fall chum spawn in streams draining to the east arm of Hood Canal. The Union and Tahuya Rivers and Rendsland, Caldervin, Stimson, Big and Little Mission, Twanoh, and Alderbrook Creeks are the main production areas. The stock is classified as a composite of native and hatchery production because of hatchery plants in the area. The stock was characterized as "healthy." From 1968 to 1991, escapement ranged from 1,200 to 21,000 fish. Average escapement from 1984 to 1991 was greater than 5,000 fish (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Southeast Hood Canal Fall Chum "healthy." From 1992 to 2001, escapement ranged from 7,175 to 75,360 fish (Washington Department of Fish and Wildlife 2003). See Maps 13 and 14 for fall chum distribution.

Coho Salmon

Hood Canal coho salmon typically enter freshwater from mid-September to mid-November and spawn from November through mid-January. Substantial numbers of hatchery-origin coho have been released into Hood Canal. Yearling plants occurred from the 1950s to the mid-1980s, and fingerling/fry plants occurred sporadically during the same time period. As of 1994, yearly releases were made from George Adams Hatchery on Purdy Creek, Hood Canal Hatchery at Hoodsport, the Quilcene National Fish Hatchery, and from net pens in Port Gamble and Quilcene Bays. Many of the early off-station releases were not consistent with current optimal-size and time-of-release strategies. The effects of these plants on wild salmon are unknown. All Hood Canal coho stocks are characterized as composites of native and non-native stocks because of the hatchery operations on the Canal. Stocks were identified based on geographic separation (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994).

The total escapement goal for Hood Canal coho is 19,100 fish. From 1967 to 1991, returns fluctuated both above and below this value. The escapement goal was not met from 1987 to 1991. Northeast Hood Canal, Dewatto, and Southeast Hood Canal coho were all showing short-term severe declines in escapement in the early 1990s. Escapement goals were not established for Hood Canal coho until the late 1970s. Prior to 1979, Hood Canal coho were managed at a harvest rate appropriate for hatchery production (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994).

Northeast Hood Canal Coho

Northeast Hood Canal coho are found in Big Anderson, Stavis, Seabeck, Little Beef, Big Beef, Kinman, Gamble, and Martha John Creeks, as well as numerous other streams depicted on Map 15. Spawning generally occurs from early November to early January. The only off-station yearling hatchery coho releases in this region occurred in Big Beef Creek in the mid-1950s to the mid-1960s. Six total off-station hatchery fingerling/fry plants occurred in Big Beef, Seabeck, or Stavis Creeks from 1955 to 1979. Since 1981, substantial numbers of extended-reared hatchery coho *(primarily Dungeness stock)* have been released in Port Gamble Bay. Tag recoveries show that these fish stray into nearby creeks when they return to spawn. The Northeast Hood Canal Stock is likely a mix of native and non-native stocks. The stock was characterized as “depressed.” In spite of an intensive coho production program on Big Beef Creek, escapements in 1990 and 1991 were the lowest and third lowest *(respectively)* on record from 1978 to 1991. The mean escapement from 1987 to 1991 was 731 fish, only 55% of the mean for the preceding nine years (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI updated rated the stock status of Northeast Hood Canal coho “healthy.” From 1992 to 2001, escapement ranged from 777 to about 4,000 fish (Washington Department of Fish and Wildlife 2003).

Dewatto Coho

Most Dewatto coho spawn from November through early January. Off-station releases of hatchery coho yearlings to the Dewatto Watershed occurred occasionally from 1954 to 1979. Fingerling/fry plants occurred infrequently from 1955 to 1979. The stock is likely a composite of native and non-native stocks. The Dewatto coho stock was characterized as “depressed.” Mean escapement from 1987 to 1990 was less than one half the mean for 1981 to 1986. The Dewatto River closed to sport fishing in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Dewatto coho “healthy.” From 1992 to 2001, escapement ranged from 3,615 to 100,879 fish (Washington Department of Fish and Wildlife 2003).

Southeast Hood Canal Coho

Southeast Hood Canal coho spawn from early November through early January. Off-station releases of hatchery coho yearlings occurred periodically from 1952 to 1976. Significant off-station fingerling/fry plants occurred from 1955 to 1984. Most releases were into the Tahuya and Union Rivers, Big Mission and Stimson Creeks, and Erdman Lake. This stock is likely a composite of native and non-native stocks. The Southeast Hood Canal coho stock was characterized as “depressed” (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). Index counts from 1988 to 1991 in the Tahuya River, Union River, and Big Mission Creek Watersheds showed escapements were one third to one half of the mean escapement for 1981 to 1986 (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Southeast Hood Canal coho “healthy.” From 1992 to 2001, escapement ranged from 2,315 to 43,315 fish (Washington Department of Fish and Wildlife 2003). See Maps 15 and 16 for coho distribution.

Fall Chinook Salmon

Hood Canal summer/fall chinook enter freshwater from late July through early October, with peak entry in late August. A small number of chinook spawn in the Union and Tahuya Rivers. Chinook enhancement programs operated by the WDFW, USFWS, and the tribes have influenced the genetic integrity of Hood Canal chinook populations. The George Adams Hatchery on Purdy Creek, Hood Canal Hatchery on Finch Creek

(Hoodsport), and Enetai Hatchery on Enetai Creek (south of Hoodsport) have released chinook in most Hood Canal streams. Hood Canal chinook have been combined as one aggregate stock because of interbreeding of hatchery and wild fish (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The primary management objective for Hood Canal chinook is attainment of hatchery escapement goals, resulting in a high harvest rate of naturally produced chinook commingled with hatchery chinook. Naturally spawning Hood Canal chinook have generally not met escapement goals over the long-term *(late 1960s to early 1990s)*. Returns to southeast Hood Canal streams, primarily the Dewatto, Tahuya, and Union Rivers, were below the escapement goal of 400 spawners. The Skokomish River produces the largest proportion of naturally spawning chinook in Hood Canal. The Hood Canal stock was characterized as "healthy" based on stable returns to the Skokomish River, but chinook runs in many of the smaller Hood Canal streams were rated "depressed." Stray hatchery chinook are believed to make significant contributions to the natural spawning populations of southeast Hood Canal streams (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). Puget Sound chinook salmon were listed as threatened under the provisions of the ESA in March 1999 (National Marine Fisheries Service 1999b). The 2002 SaSI update did not discuss chinook salmon status in watersheds included in this report. See Maps 17 and 18 for fall chinook distribution.

Pink Salmon

Small numbers of pink salmon are present in west WRIA 15. Stock status of these runs was not discussed in Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes (1994) or Washington Department of Fish and Wildlife (2003). See Maps 19 and 20 for pink salmon distribution.

Winter Steelhead Trout

Winter steelhead are present throughout west WRIA 15 and north WRIA 14, but the Dewatto, Tahuya, and Union Rivers are the main production areas. Adult steelhead enter freshwater from December through May and spawn from mid-February to early June. Low summer flows are the primary natural limiting factor of winter steelhead in these watersheds. Winter steelhead smolts have been stocked in the Dewatto and Tahuya Rivers and nearby streams, but the effects on native steelhead populations are unknown (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). From 1985 to 1989, escapement of Dewatto River winter steelhead ranged from three to 102 fish. No surveys were conducted in 1990 through 1992. The stock status was rated "depressed." The maximum sustained harvest (MSH) escapement for the Dewatto River would be 138 wild winter steelhead. However, the tribes have not agreed to this escapement goal nor the method used to derive the goal (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Dewatto River winter steelhead "depressed." From 1993 through 2001, escapement ranged from 11 to 40 fish (Washington Department of Fish and Wildlife 2003). From 1985 to 1992, escapement of

Tahuya River winter steelhead ranged from 73 to 185 fish. The MSH escapement goal is 236 fish. The stock status was rated “depressed.” The tribes have not agreed to this escapement goal nor the method used to derive the goal (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994). The 2002 SaSI update rated the stock status of Tahuya River winter steelhead “depressed.” From 1993 to 2001, escapement ranged from 75 to 340 fish (Washington Department of Fish and Wildlife 2003). Escapement of Union River winter steelhead has not been monitored and no escapement goal has been set. The stock is comprised of a historically small run of fish. The stock status was classified as “unknown” in both 1994 and 2001 (Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1994, Washington Department of Fish and Wildlife 2003). Historically, hatchery steelhead were released into Hood Canal tributaries, including the Tahuya and Union Rivers. Planting was discontinued in 1996 because of concerns about the effects of hatchery fish on wild steelhead production (Blakley *et al.* 2000). See Maps 21 and 22 for winter steelhead distribution.

Coastal Cutthroat Trout

East Hood Canal coastal cutthroat inhabit watersheds from Port Gamble Bay south and east along the Hood Canal shoreline to the town of Union. Watersheds with known cutthroat usage include several unnamed streams, Jump Off Joe Creek, Little Anderson Creek, Big Beef Creek, Little Beef Creek, Seabeck Creek, Stavis Creek, Boyce Creek, Anderson Creek, Dewatto River, Tahuya River, Shoofly Creek, Stimson Creek, Big and Little Mission Creeks, Union River, several unnamed streams on the south shore of Hood Canal, Twanoh Creek, and Alderbrook Creek. The East and West Hood Canal cutthroat stocks were separated since anadromous cutthroat prefer to travel along shorelines rather than cross deep water bodies. Both anadromous and resident cutthroat are present in the East Hood Canal stock complex. McKenna Falls on the Union River is the only known natural barrier to anadromous cutthroat migration within the range of this stock. Resident cutthroat are likely present above the falls. It is not known whether or not fluvial and adfluvial forms of coastal cutthroat are present in this stock complex (Blakley *et al.* 2000).

Spawn timing is not known, but it likely from January through April for all life histories. The East Hood Canal coastal cutthroat stock complex is native and sustained by wild production. The stock complex may be further differentiated in the future following collection of genetic, life history, and ecological information. Hood Canal coastal cutthroat are believed to be genetically distinct from North Puget Sound coastal cutthroat. Genetic samples from coastal cutthroat trout were recently collected from Big Beef, Seabeck, Stavis, Gold, Little Anderson, Stimson, Little Mission, Big Mission, unnamed streams (15.0498, 15.0504, and 15.0507), Courtney, and Bear Creeks. The Stavis and Gold Creek samples were genetically distinct from each other and the West Hood Canal stock complex (Blakley *et al.* 2000).

The year 2000 SaSI Coastal Cutthroat Trout report characterized the stock status of East Hood Canal coastal cutthroat as “unknown” (Blakley *et al.* 2000). Long-term monitoring information was insufficient to assess the stock status. Natural hybridization of coastal cutthroat trout and steelhead has been observed in Big Mission Creek (Campton and Utter 1985, cited in Blakley *et al.* 2000). Streams that support anadromous coastal cutthroat and recreational fisheries are subject to a 14-inch minimum size limit to protect first-time spawners and some repeat spawners. Catch-and-release of wild cutthroat and steelhead is also required. From 1970 to 1991, hatchery cutthroat developed from fish captured in Thorndyke and Dabob Bays were released into Hood Canal and several East Hood Canal streams, including the Dewatto, Tahuya, and Union Rivers, and Big Mission Creek. The stocking program was discontinued in 1991 because of poor survival and low catches by recreational anglers. Resident cutthroat fry and catchable-sized fish from Tokul Creek stock *(Snohomish River)* are released annually in many lakes and beaver ponds on the Kitsap Peninsula. Interaction between these fish and wild resident cutthroat is believed to be very minimal (Blakley *et al.* 2000). See Maps 23 and 24 for coastal cutthroat distribution.

Bull Trout/Dolly Varden Char

Bull trout *(Salvelinus confluentus)* and Dolly Varden *(S. malma)* are not known to be present in west WRIA 15 nor north WRIA 14 (Washington Department of Fish and Wildlife 1998). No record of historic presence is known to exist. Bull trout and Dolly Varden are typically found in streams that maintain cold water temperatures year-round, at least in headwater tributaries (Behnke 2002). The rainfall-dominated streams of west WRIA 15 and north WRIA 14 do not provide this type of habitat.

HABITAT LIMITING FACTORS IDENTIFICATION

This report was developed by synthesizing written habitat descriptions, data derived from field assessments of habitat, and personal communications from natural resource professionals with knowledge of the West Kitsap Basin and North Kennedy-Goldsborough Subbasin. Many of these personnel served in various capacities on the Technical Advisory Group (TAG), which contributed large amounts of literature, data, and technical review to this project. The report is intended for use as a tool to guide and prioritize salmonid habitat restoration projects. It is a compilation of all the information available at the time of writing. The report is a working document and should be viewed as a characterization of habitat conditions in the year 2003. Habitat conditions will undoubtedly change over time and data gaps will be filled periodically. The reader is encouraged to consult the "Co-Managers" (Washington Department of Fish and Wildlife, the Skokomish Tribe, and the Port Gamble S'Klallam Tribe) to verify the validity of habitat conditions as time progresses.

Habitat descriptions, assessments, and TAG knowledge were used to describe current habitat conditions in watersheds throughout the region. These descriptions were compared to the West WRIA 15/North WRIA 14 salmonid habitat rating criteria (Table 13), resulting in a good, fair, or poor rating of habitat quality averaged throughout the entirety of each watershed (Table 14). A summary of riverine habitat limiting factors is found in (Table 15). It is important to note that information on habitat conditions was often limited, and in some cases non-existent. The professional expertise of the TAG was used to fill in some of these "data gaps." However, in some cases no information was available. In these cases the habitat condition appears as a data gap (DG) in (Table 14). The habitat descriptions and habitat ratings were used to develop recommendations. These recommendations are not intended as regulatory mandates. These actions are necessary to restore and/or protect salmonid habitat in West WRIA 15 and North WRIA 14. Implementation of some of the recommendations will require creative thinking, compromise, and in some cases sacrifices.

Nearshore/estuarine habitat conditions were assessed through evaluation of oblique aerial photos of the shoreline, use of a GIS to compare recent (1994 or later) habitat conditions to historic (1880s) topographic charts, and analysis of data from a shoreline assessment performed by the Point No Point Treaty Council. For a more thorough description of methods, see the "Nearshore/Estuarine Habitat Data" section below. The TAG evaluated nearshore/estuarine habitat conditions based on known stressors and effects (Table 32) and developed prioritized nearshore action recommendations (Table 33) intended to improve and/or maintain natural nearshore habitat functions.

Data Sources and Assessment Methods

Riverine Habitat Data

This report is a compilation of information gathered from multiple entities. In some cases, the entities used different methods during habitat assessments. Data reported from (Bernthal and Rot 2001) were gathered from the Tahuya and Dewatto Rivers during the summer of 1994. The surveys followed the Timber-Fish-Wildlife Ambient Monitoring Program protocols (Northwest Indian Fisheries Commission 2003). The Tahuya River was surveyed from RM 4.1 to RM 7.4, while the Dewatto was surveyed from RM 3.0 to RM 7.7. Data were not recorded in the three wetlands present within the surveyed reach of the Dewatto River. Therefore the values used in this report are representative of instream channel conditions only.

The Hood Canal Salmon Enhancement Group (HCSEG) conducted extensive instream habitat inventories in the Dewatto, Tahuya, and Union River Watersheds from the late 1990s to the present. Field surveys followed the protocols outlined in Cederholm and Scarlett (1997). The HCSEG field crew is trained annually to be proficient with this methodology (Boad 2003, Personal communication).

The author used ArcView GIS 8.2 to calculate road densities. Road lengths were calculated from the Washington Department of Natural Resources (DNR) transportation GIS layer (scale = 1:24,000). This data set was obtained from DNR in the year 2002. Watershed areas were calculated from polygons digitized by the author at 1:24,000 scale or larger (for example, 1:12,000). The DNR transportation layer may not depict all roads in the study area; therefore road densities are likely underestimated.

“The West Kitsap Watershed Analysis,” (Washington Department of Natural Resources 1995), contained information regarding riverine habitat conditions in watersheds from Little Anderson Creek south to Thomas Creek. Information on riparian habitat conditions was gathered primarily by analysis of aerial photographs. Instream habitat data were compiled largely from inventories conducted by the Point No Point Treaty Council. A geologist performed sediment budget analyses.

Much of the information cited as May and Peterson (2002) is a compilation of data collected by the Point No Point Treaty Council in 1993-94 and Chris May (PhD fisheries consultant) in 1996-97. Large woody debris values were reported as pieces per kilometer. The author converted the values to pieces per meter for use in this report. In many cases, “The Kitsap Peninsula Salmonid Refugia Report-Peer Review Draft” did not include specific habitat data for individual watersheds. However, habitat conditions were rated in Appendix C of the refugia report (Table 35, Appendix D of this report). A habitat assessment score sheet included in the refugia report appendix assigned broad habitat condition categories to each habitat rating (Table 36, Appendix D of this report). The narratives citing ratings from May and Peterson (2002) were created by the author converting the habitat ratings in Table 35 to the narrative categories listed on the habitat assessment score sheet Table 36. While conclusions derived from this exercise are not as robust as those supported by actual habitat data, in many cases this was the only information available to describe habitat conditions. In this regard, the narratives provide a general appraisal of habitat conditions. Field assessments of habitat conditions are needed in many of the watersheds discussed in this report, particularly in the drainages of the numerous small-independent streams (TAG 2003).

Very little information was available regarding water quality and water quantity. With the exception of Big Beef Creek, most stream gaging station data were collected between 1945 and the late 1950s (Washington Department of Natural Resources 1995).

Nearshore/Estuarine Habitat Data

Topographical charts were created by the United States Coast and Geodetic Survey for the Hood Canal shoreline during the mid-to-late 1800s. These charts are commonly referred to as "T-sheets" and identify spits, salt marshes, mudflats, high and low tide lines, and broad vegetation types along the shoreline. The Point No Point Treaty Council (PNPTC) created a GIS layer that illustrates these historic habitat features. This GIS layer was overlaid on top of 1994 digital orthophotos to identify historic habitats lost to shoreline development. Information obtained from this exercise is cited as: (Point No Point Treaty Council 2003, Unpublished work).

The Washington Department of Ecology (DOE) flew along the entire coastline of Washington in the year 2000 to take oblique aerial photos. These photos illustrate nearshore habitat conditions along the entire coastline discussed in this report. Information obtained from these aerial photos is cited as: (Washington Department of Ecology 2000b). The TAG evaluated these aerial photos during the course of three all-day meetings. Conclusions reached from assessment of these photos are the result of the TAG exercises, not work performed by the Washington Department of Ecology.

"Shoreline Alterations in Hood Canal and the Eastern Strait of Juan de Fuca," (Hirschi *et al.* 2002), was a field assessment of shoreline habitat conditions along the entire shoreline of Hood Canal and the eastern Strait of Juan de Fuca to Dungeness Spit. Fieldwork was conducted from August 1999 to December 2000. Information was gathered from a boat traveling along the shoreline at or near high tide, 30 to 100 meters from shore. Features recorded included docks, jetties, launch ramps, stairs, marinas, changes to backshore landform (example: fill), bulkheads, and backshore zone composition (high bluff [>30 feet high], low bluff [<30 feet high], beaches/spits/berms, salt marsh, and uplands). This information was entered into a GIS and snapped to the Department of Ecology's driftcell GIS layer. Data from the appendices of Hirschi *et al.* (2002) were reported by individual driftcell. These values were organized and summarized by the author to describe conditions along the shoreline reaches designated in this report.

Riverine Habitat Limiting Factors Assessed

Access and Passage

Artificial Barriers

Artificial obstructions can block salmonid migration up and down streams. Depending on the location and longevity of the barrier, the negative effect may be limited to a portion of only one generation, or in extreme cases, the barrier may cause the extirpation [def.] of an entire run of fish. Man-made structures that may hinder salmonid migration in west WRIA 15 and north WRIA 14 include dams and failed culverts. Natural waterfalls and cascades are common in headwater areas (Figure 1).

Figure 1. Culvert near RM 1.0 on Windship Creek (15.0436), left bank tributary at RM 7.7 of the Dewatto River. This culvert is a partial barrier to adult and juvenile salmonids. Beaver ponds upstream provide quality salmonid rearing habitat. Photo courtesy of Marty Ereth, Skokomish Tribe.

Floodplains

Floodplain Connectivity

Floodplains provide an area for dissipation of energy in floodwaters. The floodplain has a larger surface area, and generally flatter slope than the stream channel. Once floodwaters spill onto the floodplain, the water spreads out, loses energy, and deposits fine sediment. Collisions between water and riparian vegetation reduce energy even further. Confining streamflows through channelization, and diking increases stream energy (and the potential for serious flooding downstream) by negating the benefits of water dispersing onto the floodplain (Ziemer and Lisle 2001). Increased stream energy causes bank erosion that leads to over-widening of the channel and aggradation of sediment. It can also cause channel incision that leads to loss of spawning gravels and lowering of the water table (Rosgen 1996). Beaver ponds, wetlands, oxbow ponds, and side channels connected to the main river channel are all forms of off-channel habitat. Juvenile salmonids (especially coho salmon, and cutthroat trout, and to a lesser extent, rainbow/steelhead trout) seek out this type of habitat for rearing, particularly during winter high flows. Off-channel areas connected to mainstem streams provide an abundance of food with fewer predators than would typically be found in the larger stream. These areas also generally have reduced current and large amounts of vegetative and/or woody cover, allowing juvenile salmonids to hide from predators and conserve energy (Sandercock 1998). Diking, and channelization of rivers, conversion of riparian zones to pasture and cropland, floodplain development, and extermination of beaver all play a roll in destruction of off-channel habitat (Figure 2).

Figure 2. Beaver pond in the Sherwood Creek Watershed (outside the report are in south WRIA 14). Beaver ponds provide excellent rearing habitat for coho salmon and cutthroat trout. Abundant woody debris provides cover, while the pond provides shelter from low summer and high winter flows. Photo courtesy of the Allyn Salmon Enhancement Group.

Loss of Floodplain Habitat

Floodplains are often host to ponds, wetlands, and side channels. When connected to the stream, these off-channel areas provide both adult and juvenile salmonids refugia during floods (Benda *et al.* 2001), and may be used by rearing salmonids for long periods of time depending upon the species. Functional floodplains moderate instream flow peaks by substantially increasing the area available for water storage (Ziemer and Lisle 2001). Water seeps into the groundwater table during floods, recharging wetlands, off-channel areas and shallow aquifers. Wetlands and aquifers in turn release water to the stream during the summer months through a process called hydraulic continuity (Water Facts Group 1997). This process ensures adequate flows for salmonids during the summer months, and reduces the possibility of high-energy flood events that can destroy salmonid redds during the winter months. Floods are a natural riverine process that is vital to maintaining stream function. Flood flows flush fine sediment from spawning gravel, create pools and riffles by reshaping the streambed, deposit fine sediment on the floodplain, and move large woody debris from the floodplain to the stream channel (Benda *et al.* 2001). However, frequent catastrophic floods are not a natural phenomenon. These events are typically caused by human-induced changes in watershed cover such as extensive logging, extension of the channel network by high road densities, or alterations of channel morphology (Ziemer and Lisle 2001).

Channel Conditions

Fine Sediment

Substrate embeddedness is the product of fine sediment washed into streams. Eroding streambanks, forestland, roads, and urban developments all contribute fine sediment inputs to streams in west WRIA 15 and north WRIA 14. Ideal salmonid spawning habitat has very little substrate embeddedness (Figure 3). When fine sediment settles to the bottom it cements gravels and cobbles together forming a type of "pavement." This pavement makes it difficult for female salmonids to excavate their redd. Highly embedded substrate also prevents juvenile or sub-adult salmonids from entering or exiting interstices in the substrate that provide important winter cover. An abundance of fine sediment reduces the amount of water able to circulate through the gravel deposited over the eggs in the redd. This water infiltration is critical to oxygen delivery to the developing salmonids and removal of fish wastes from the nest (Bjornn and Reiser 1991, Hicks *et al.* 1991).

Figure 3. Clean gravel at Port of Dewatto on Dewatto River, December 2002. Substrate at this site was very loose. Recent chum salmon spawning activity likely enhanced this condition. Photographed by the author.

Large Woody Debris

Large woody debris or (LWD) is an important component of stream habitat. Large trees that fall into streams, or are carried in by landslides and floods stabilize streambeds, collecting spawning gravels and encouraging pool formation. Woody debris also provides cover for salmonids and their prey (Figure 4). In the past woody debris was removed from streams to aid navigation, ease transport of logs, speed floodwaters downstream, or remove barriers to salmonid migration. Large woody debris is lacking in many streams because of these activities (Sedell *et al.* 2000) and the reduction or modification of riparian vegetation (Knutson and Naef 1997). Unfortunately woody debris recruitment is a long-term process since it first requires the presence of a functioning riparian zone comprised of large trees, and second, a means of getting the tree into the stream (i.e. flood, wind storm, landslide, beaver falling a tree, etc.) (Benda *et al.* 2001). Prior to extensive timber harvest an estimated 60 to 70% of Pacific Northwest forests were composed of late successional trees (>200 years old) (Franklin and Spies 1984, Booth 1991). Recent surveys of commercial timberlands in western Washington revealed a majority of riparian zones dominated by immature trees (mean diameter at breast height was 8 to 12 inches). Red alder was the dominant tree species (Carlson 1991). Coniferous trees produce the most desirable woody debris both in terms of size

(Murphy and Koski 1989) and longevity. Western redcedar provides the most decay-resistant woody debris, followed by Douglas-fir, western hemlock, and red alder (Swanson and Lienkaemper 1978).

Figure 4. Large woody debris at Port of Dewatto on Dewatto River. The wood at left provides overhead cover, while the rootwad at the right has created a pool where fish can rest. The wood at left will be submerged during high water, providing shelter from high flows. Photographed December 2002.

Percent Pools & Pool Frequency

Pools are important habitat for salmonids and their prey. Salmonids use pools for resting during migration, rearing, hiding cover, feeding, and spawning in tailouts or current edges. Pools are characterized by calm water and can range in size from one foot deep and a few feet of surface area to 10 feet or greater in depth with a substantial surface area depending upon the size of the stream.

Pool Quality

Important features of pools are size, depth, and cover (both instream and overhead). Generally speaking, the more size, depth, and cover that are present, the higher the quality of the pool. Large-deep pools with lots of cover provide many hiding areas, ample forage, and cool water temperatures. An abundance of pools interspersed with riffles combine to create ideal salmonid habitat (Figure 5).

Figure 5. Pool at Port of Dewatto on Dewatto River, December 2002. Large woody debris provides both overhead and submerged cover. Water depth and cover in this pool would provide suitable habitat for adult and juvenile salmonids. Photographed by the author.

Streambank Stability

Natural streambank stability maintains the integrity of riverine processes. The root masses of riparian vegetation and large woody debris stabilize streambanks (Figure 6). Riparian zones can maintain or repair themselves if they are located on a stable bank. Vegetation has a difficult time recovering from flood damages or other disturbances if it is continually undermined by a failing bank (Naiman *et al.* 2001). Stable streambanks also ensure an adequate channel depth. A given volume of water is deeper in a narrow channel than in a wide channel. Depth maintains the cool temperatures and hiding cover needed by salmonids. Rapidly eroding banks tend to lead to development of overly wide and shallow channels (Platts 1991). Eroding streambanks can contribute large amounts of fine sediment to the water column as well as large amounts of coarse sediment that is deposited in the stream channel (aggraded), thus leading to subsurface flows (Hicks *et al.* 1991, Ziemer and Lisle 2001). Fine sediment appears to have little negative effect on adult salmonids (unless levels are chronically high), but it smothers developing juvenile salmonids buried in the streambed and fills interstices between gravels, cobbles, and boulders that provide important winter cover (Bjornn and Reiser 1991) (See Fine Sediment).

Figure 6. Upper Tahuya River downstream from Tahuya Lake, early December 2002. Shrubs and trees in the riparian zone stabilize streambanks. Photo courtesy of Marty Ereth, Skokomish Tribe.

Sediment Input

Streams naturally erode and transport sediment. Natural sediment supply rates can vary considerably depending upon the physical size, topography, and geology of a watershed (Rosgen 1996, Montgomery and Buffington 2001). Land use activities such as logging and road building on steep slopes can reduce soil stability, leading to mass wasting (landslides) (Washington Department of Natural Resources 1995). Removal of riparian vegetation through logging, residential and urban development, and agricultural activities can reduce streambank stability. Roads intercept precipitation and prevent it from infiltrating the soil. The transportation network effectively increases the drainage network, causing accelerated stormwater runoff and associated soil erosion. All of these activities can lead to elevated sediment inputs (Meehan 1991).

Riparian Zones

Riparian zones are the interface between the aquatic and terrestrial environments. This zone is normally covered with lush vegetation ranging in composition from grasses and forbs to shrubs and large trees depending upon the location within a watershed. Riparian zones have several important functions in maintaining natural riverine processes. Tree and shrub roots hold streambanks together (Montgomery and Buffington 2001) with a "root matrix." This matrix stabilizes channels, enabling the formation of undercut banks (excellent fish habitat) and reduces erosion (fine sediment smothers juvenile salmonids developing in streambed gravels) (Bjornn and Reiser 1991). Overhanging tree canopies shade water (Naiman *et al.* 2001), maintaining the cool temperatures salmonids need to thrive (Bjornn and Reiser 1991). Leaf litter falling into the stream is an important component of primary production within the aquatic community (Bisson and Bilby 2001), although Murphy (2001) asserts that aquatic plants and algae make a larger contribution. Microinvertebrates (i.e. zooplankton) and macroinvertebrates (larval insects, aquatic snails, etc.) feed on the decomposing organic material. Fish and other animals in turn feed on the smaller organisms (Bisson and Bilby 2001). Mature trees in the riparian zone also provide important function when they are knocked into streams by floods, windthrow, or landslides. These woody materials are known as large woody debris (LWD). Large woody debris stabilizes streambeds and banks, captures spawning gravels, encourages pool formation, provides resting and hiding cover for salmonids, and creates habitat for insects and other forage important to salmonids (Bilby and Bisson 2001). Finally vegetation within the riparian zone filters soil and pollutants from stormwater runoff (Knutson and Naef 1997, Welch *et al.* 2001) and reduces flood damage by slowing down flood waters, thereby dissipating energy and capturing soil carried in the flood waters (Naiman *et al.* 2001) (Figure 7).

Figure 7. Riparian vegetation at Port of Dewatto on Dewatto River, December 2002. Shrubs and trees stabilize streambanks and provide shade to maintain cool water temperatures. Also note the large woody debris recruited from mature trees in the riparian zone. Photographed by the author.

Water Quality

Salmonids require cold and clean water for optimal survival. Temperature, dissolved oxygen (DO) concentration, total suspended solids (TSS), pH, and other variables are all important elements of water quality. Water temperature requirements vary depending upon salmonid lifestage and species, but in general, a range of 50-57°F (10-14°C) is preferred. Long-term exposure to temperatures greater than 75°F (24°C) is fatal to salmonids (Bjornn and Reiser 1991). Salmonids require a minimum dissolved oxygen concentration of 5 mg/L (also read as [ppm] or parts per million) for survival (Bjornn and Reiser 1991). Washington State water quality standards require a value of 8 mg/L of DO for protection of fish resources in Class A waters and 9.5 mg/L in Class AA waters (WAC 173-201A). Total suspended solids (TSS) refers to the weight of particles including soil, and algae suspended in a given volume of the water column (Michaud 1991). The U.S. Fish and Wildlife Service recommends a maximum TSS level of 80 mg/L to protect salmonid fish (Fish and Wildlife Service 1995). Other water quality parameters including pH, the concentration of hydrogen ions in water, and chemical pollution can degrade habitat quality.

Hydrology

Flow-Hydrologic Maturity

Hydrologic maturity refers to the stand age of a watershed's vegetation. For the purposes of this report, hydrologically mature forests have a stand age greater than 25 years old. Hydrologically immature forests are less than 25 years old. Mature forests moderate stormwater runoff. Clearcuts and roads tend to convert subsurface flow to overland flow, leading to increased runoff rates and volumes (Ziemer and Lisle 2001).

Flow-Percent Impervious Surfaces

Roads, driveways, and rooftops are examples of impervious surfaces. These surfaces intercept precipitation, preventing infiltration of water into the groundwater table. Increased runoff during the wet season often damages instream salmonid habitat and human infrastructure. Decreased groundwater recharge exacerbates low flow conditions during the summer months. Summers in this region are relatively dry and ground water supplies are almost entirely recharged from precipitation. Groundwater provides the majority of late summer flow to area streams (Molenaar and Noble 1970). The natural climate, degraded watershed conditions, and surface and groundwater withdrawals may all contribute to low and/or subsurface stream flows. If flows are too low or channels are completely dewatered, little or no quality habitat remains for salmonids. Low summer flows limit salmonid rearing habitat throughout the report area (Williams *et al.* 1975, Blakley *et al.* 2000). As flows decrease, water temperatures usually increase. Migration is hindered or completely blocked and fish are more vulnerable to predation and competition for limited space (Figure 8). Extensive logging and construction of impervious surfaces have likely altered the natural flow regime in west WRIA 15 and north WRIA 14 by increasing runoff and peak stream flows during the winter months, and reducing stream flows during the summer months.

Figure 8. Upper Tahuya River below Tahuya Lake, early December 2002. Stream flows were still low at the time since the winter rains had not arrived. During the dry season, groundwater and wetlands provide the majority of flow to streams within the report area. Photograph courtesy of Marty Ereth, Skokomish Tribe.

Biological Processes

Nutrients

Anadromous salmonids returning from the ocean are a valuable source of nutrients to watersheds which are often nutrient limited (McClain *et al.* 2001). Nutrients from decomposing salmon carcasses are a critical component of aquatic (Bisson and Bilby 2001) and terrestrial food webs (Reeves *et al.* 2001) (Figure 9).

Biological Diversity

Biological diversity examines issues such as the presence of introduced plant or animal species that may have a negative effect on salmonids (i.e. reed canary grass, brook trout, smallmouth bass) as well as the absence of native species that were historically present. Introduced plants and noxious weeds can out-compete native vegetation, reducing the quality of riparian plant communities (Knutson and Naef 1997). Introduced fish species may out-compete, hybridize with, or eat native salmonids. Removal of native species can disrupt ecosystem functions (McClain *et al.* 2001). For example, beaver create and maintain significant amounts of salmonid rearing habitat through dam construction. Beaver ponds are excellent salmonid rearing habitat and they gradually release water to streams, helping to maintain summer flows (Lichatowich 1999). Unfortunately, some people view beaver dams as barriers to salmonid migration and flood nuisances and therefore either destroy the dam or trap the beaver.

Figure 9. Chum salmon carcasses at the mouth of Twanoh Creek, December 2002. Decaying carcasses from spawned-out salmon provide ocean-derived nutrients that benefit many organisms in Pacific Northwest watersheds. Photographed by the author.

Nearshore Habitat Limiting Factors Assessed

Shoreline Armoring

Filling of tidelands and bulkhead construction are the most conspicuous shoreline alterations along Hood Canal (Yoshinaka and Ellifrit 1973). In the year 2000, bulkheads were present along more than 70% of the south shore of the east arm of Hood Canal (Hirschi *et al.* 2002). Surf smelt and sand lance, important forage fish for anadromous salmonids, spawn near the high tide level on sand and gravel beaches. This portion of the beach is exposed to harsh conditions during low tides. Surface temperatures routinely exceed 100°F. If the beach is not shaded by riparian vegetation, thermal trauma and desiccation can cause significant mortality of surf smelt and sand lance eggs. Shoreline development impacts forage fish production through burial of spawning habitat with intertidal fill and armoring as well as degradation of spawning beaches through clearing of riparian vegetation (Penttila 2001). By the early 1970s, more than half of the historic surf smelt spawning beaches in Hood Canal were estimated to have been lost to shoreline development (Yoshinaka and Ellifrit 1973). In addition to reducing forage fish production, shoreline armoring alters nearshore habitats and salmonid behavior. Bulkheads and roads adjacent to shorelines limit sediment recruitment from bluffs and alter littoral drift of beach sediments. Sediments and woody debris contributed by eroding bluffs are important for maintenance of beaches and spits along the Hood Canal shoreline. Littoral drift often carries sediments long distances from the recruitment site (i.e. bluff). Because of this, the effects of reduced sediment recruitment are often manifested down drift from the armoring site rather than at the site that eliminated sediment recruitment (TAG 2003). See Figure 10. Eelgrass beds provide prey habitat and foraging opportunities for juvenile salmonids, and are thus important juvenile salmonid migratory corridors. Coarsening of substrate caused by beach armoring can lead to fragmentation or complete loss of eelgrass beds. Intertidal bulkheads can force juvenile salmonids from the shallows into deeper water where they face increased predation risk (Simenstad 2000).

Figure 10. Eroding bluff just north of the mouth of Harding Creek. Eroding bluffs provide sediment and large woody debris critical to maintenance of shoreline landforms along Hood Canal. Ecology oblique aerial photo number 010426-151428 (Washington Department of Ecology 2000b).

Docks and Piers

The shoreline of Hood Canal is a popular site for residential development. In particular, the north and south shores of the east arm of the canal have been extensively developed for residential use (Yoshinaka and Ellifrit 1973, Brody 1991, Washington Department of Ecology 2000b). Docks limit, or eliminate eelgrass beds through shading and the physical structures of the docks themselves. They can also alter juvenile salmonid behavior, forcing fish from the shallows into deeper water where they are more vulnerable to predation (Simenstad 2000). Many of the docks on lower Hood Canal are large, exceeding 400 square-feet, to compensate for small residential lot size (Small 2003, Personal communication). Naturally, docks and piers are often accompanied by boats. Propeller scour from boats can damage benthic communities and remove eelgrass (Simenstad 2000). Individual residences frequently have a private pier and/or dock. In many cases the water craft in use at these docks are small enough to store on land and trailer to a public boat launch (TAG 2003). See Figure 11.

Figure 11. Each residence along Hood Canal often has its own pier and dock. These homes are along SR 106 on the east arm of Hood Canal. Photo number 010626-151838 (Washington Department of Ecology 2000b).

Stormwater/Wastewater

With the exception of the town of Port Gamble, the Bangor Naval Station, and the Alderbrook Inn, all residences along Hood Canal depend upon septic systems to treat sewage (Brody 1991). Leaking septic tanks lead to nutrient enrichment that encourages growth of macroalgae. Decomposition of the macroalgae leads to high biological oxygen demand (Simenstad 2000). Conversion of forests to residential developments results in the creation of impervious surfaces including roads, driveways, parking lots, and rooftops. Impervious surfaces reduce water infiltration into the soil, forcing the water to flow over the ground surface. Stormwater runoff is often contaminated with soil and pollutants including oil and antifreeze from cars and fertilizer, herbicides, and pesticides from lawns. See Figure 12.

Figure 12. Port Gamble Log Mill and the community of Port Gamble. Impervious surfaces and lawns likely contribute pollutants to Hood Canal. Port Gamble is one of the few communities in the report area with a sewage treatment plant, which should minimize wastewater impacts. Ecology oblique photo number 010426-144112 (Washington Department of Ecology 2000b).

Landfill

Intertidal fill can force juvenile salmonids from the shallows to deeper water where they face increased predation risk (Simenstad 2000). See "Shoreline Armoring" above. Filling along the Hood Canal shoreline has destroyed numerous salt marshes, lagoons, and spits, and reduced tidal influence in many streams (Washington Department of Ecology 2000b, Point No Point Treaty Council 2003, Unpublished work). See Figure 13. These habitats are vitally important to juvenile salmonids rearing in the estuarine environment (Groot and Margolis 1998, Aitkin 1998, Simenstad 2000). A recent study of the tidally influenced portions of small streams and independent marshes in Hood Canal documented juvenile salmonids rearing in these habitats throughout the year. The overall regional significance of these habitats is presently not understood. Although tidal creek and independent marsh habitats are relatively small in size when compared to the greater Hood Canal area, their contribution to juvenile salmonid production should not be overlooked. These habitats are an important component of the estuarine landscape (Hirschi *et al.* 2003).

Figure 13. The present site of the Miami Beach community was historically home to a spit, intertidal wetland, and four acre salt marsh. Ecology oblique photo number 010426-150222 (Washington Department of Ecology 2000b).

Riparian Buffers

Riparian vegetation stabilizes the shoreline along Hood Canal, provides large woody debris recruited through windfall and landslides, slows runoff, filters soil and pollutants from stormwater, and provides shade important to maintaining cool water temperatures. Removal of riparian vegetation reduces shade and large woody debris recruitment. This loss of shade and LWD leads to a reduced supply of terrestrial insects, epibenthic prey, and loss of forage fish spawning habitat (Simenstad 2000). See Figure 14.

Figure 14. Mature coniferous riparian forest buffer at Spear-Fir Lagoon. Ecology oblique photo number 010426-150342 (Washington Department of Ecology 2000b).

Tidal Processes

Diking and landfill were used to create land for residences and farming during settlement of the Hood Canal region. These systems have significantly altered tidal processes, eliminating nearshore features at many locations along the Canal (Small 2003, Personal communication). Filling and residential development along the Hood Canal shoreline have constrained the lower reaches of many streams (Washington Department of Ecology 2000b). These channel constrictions cause a host of problems including reduced tidal influence into the stream, reduced meandering of the stream across its delta (often resulting in channel aggradation and flooding of adjacent homes), reduced productivity in the stream and adjacent marshes, and interference with salmonid migration (TAG 2003). See Figure 15. Diking can also damage eelgrass beds (Small 2003, Personal communication). Eelgrass beds provide prey resources and protection from predators, and essentially serve as “bridges” between the large rearing habitats on deltas (Simenstad 2000).

Figure 15. Tidal influence in Big Beef Harbor has been severely constrained by the Seabeck Highway. Ecology oblique photo number 010426-145346 (Washington Department of Ecology 2000b).

PORT GAMBLE SUBBASIN HABITAT LIMITING FACTORS

Subbasin Description

The Port Gamble Subbasin covers 66 square miles of the extreme northern portion of west WRIA 15. See Map 3. With the exception of Gamble Creek, most streams are very short. The terrain is dominated by gently rolling hills generally less than 400-feet elevation. Many shorelines along Hood Canal have steep side slopes. Settlement of this subbasin is less dense than that found to the south and east on the Kitsap Peninsula. Residential communities are located at Port Gamble and Lofall. Homes and farms are scattered throughout the subbasin. Settlement has been concentrated along the shoreline of Hood Canal. Watershed and streambank cover are generally favorable because of only moderate levels of development. Forests are comprised of a mix of second growth coniferous and deciduous trees with an understory of thick brush. The short streams generally have steep gradients and small discharges. The longer streams generally have moderate gradients and gravel substrate with some fine gravel and sand. These streams have relatively narrow fluctuations in flow. Gamble and Kinman Creeks are the largest streams in the subbasin (Williams *et al.* 1975). Descriptions of individual watersheds are located in the habitat description of each stream.

Hawks Hole Creek (15.0347) Watershed

Description

Hawks Hole Creek enters Hood Canal about 0.7 of a mile south of Coon Bay. The stream is about 1.8 miles in length (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No barriers to fish migration are known to be present in the Hawks Hole Creek Watershed. However, an extensive barrier inventory has not taken place (Todd 2003, Personal communication). May and Peterson (2002) rated artificial barriers fair, which corresponds to lost access to 10 to 20% of the watershed. Artificial barriers were rated good to fair. See Map 25.

Floodplains

Floodplain Connectivity

The lower 200 meters of Hawks Hole Creek was straightened and adjacent salt marsh and tidal channels were filled. This development is believed to have occurred in the 1960s to early 1970s in association with the nearby Shorewoods Community. Floodplain habitat upstream is believed to be in a natural condition (Todd 2003, Personal communication).

May and Peterson (2002) rated floodplain conditions fair, which corresponds to 25 to 50% loss of floodplain connectivity. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

Salt marsh and tidal channel habitats filled in the lower 200 meters of stream during the 1960s-70s represent an opportunity to reclaim lost habitat. The fill could be removed and off-channel/tidal channel habitat could be recreated (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions fair, which corresponds to 25 to 50% of floodplain area altered or lost. Loss of floodplain habitat was rated poor to good.

<u>Channel Conditions</u>

Fine Sediment

May and Peterson (2002) rated fine sediment levels fair, which corresponds to a fine sediment level of 15 to 20%. Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment levels were rated fair to poor.

Large Woody Debris

Large woody debris is sparse from the mouth upstream to Hood Canal Drive (approximately 500 meters) (Todd 2003, Personal communication). May and Peterson (2002) rated LWD quantity fair, which corresponds to sparse or infrequent LWD abundance. Large woody debris abundance was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair, which corresponds to 20 to 30% pool surface area. Percent pools were rated poor.

Pool Frequency

Pools are lacking from the mouth upstream to Hood Canal Drive (Todd 2003, Personal communication). No additional information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, which corresponds to a condition of few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability fair, which corresponds to stable banks along 50 to 75% of the stream. Streambank stability was rated poor.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Hawks Hole Creek Watershed was 5.3 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Shrubs, lawns, and deciduous trees are the dominant riparian vegetation along the lower 500 meters of stream. Few mature coniferous trees are present on this reach (Todd 2003, Personal communication). Riparian habitat ratings in May and Peterson (2002) correspond to a riparian buffer that has been impacted by some encroachment (i.e. moderate buffer width), comprised of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

<u>Water Quality</u>

Temperature

No water temperature data were available, but degraded channel conditions in the lower 200 meters of stream suggest that high water temperatures may occur during the summer and early fall (Todd 2003, Personal communication). The Port Gamble S'Klallam Tribe will be monitoring water temperatures during the summer of 2003 (Labbe 2003, Personal communication).

Dissolved Oxygen

No dissolved oxygen data were available, but channel degradation in the lower 200 meters of stream suggest that low dissolved oxygen levels may occur during the summer and early fall (Todd 2003, Personal communication).

<u>Hydrology</u>

Flow-Hydrologic Maturity

No information was available.

Flow-Percent Impervious Surfaces

The upper watershed is fed by fairly extensive wetlands and beaver ponds, and should be protected. The middle watershed is subject to more recent logging (last 25 years) and residential development. Close attention should be given to providing adequate riparian corridor protection, minimizing road crossings and road-related resource impacts, and stormwater drainage from impervious surfaces to Hawks Hole Creek and its tributaries (Todd 2003, Personal communication).

<u>Biological Processes</u>

No biological processes information was available.

Jukes Creek (15.0348) and Shipbuilders Creek (15.0349) Watersheds

Description

Jukes Creek (Hansville Creek) enters Hood Canal about one mile south of Hawks Hole Creek. The stream is about 1.9 miles in length with numerous small tributaries. Shipbuilders Creek enters Hood Canal about 1.5 miles south of Unnamed Stream 15.0348. The stream is 1.8 miles long with several tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A perched culvert under the Hood Canal Drive crossing of Jukes Creek (RM 0.05) is a complete barrier to anadromy. The extent of historic anadromous use of Jukes Creek is uncertain since the lower stream reach has a steep gradient of 8 to 20%. However, the culvert and habitat upstream should be assessed for a potential passage improvement project (Todd 2003, Personal communication). A culvert at the Little Boston Road crossing of Shipbuilders Creek (RM 0.45) is a partial barrier. Cutthroat have been observed in a pool downstream from the culvert (Todd 2003, Personal communication). Artificial barriers were rated poor. See Map 25.

Floodplains

Floodplain Connectivity

Where present, floodplains along Jukes Creek are functioning naturally. The mouth of Shipbuilders Creek is confined by fill, and fill at the Little Boston Road Crossing has eliminated a portion of the floodplain. Floodplains along the remainder of Shipbuilders Creek are functioning naturally (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions good, with <10% loss of connectivity. Floodplain connectivity was rated good.

Loss of Floodplain Habitat

Filling at the mouth of Shipbuilders Creek and under the Little Boston Road crossing have eliminated a small amount of floodplain habitat (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions good (<10% of habitat lost). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment fair, equivalent to a fine sediment level of 15 to 20%. Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to poor.

Large Woody Debris

May and Peterson (2002) rated LWD abundance fair, which corresponds to sparse or infrequent abundance. Large woody debris abundance was rated poor.

Percent Pools

May and Peterson (2002) rated percent pools fair, which equates to 20 to 30% pool surface area. Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, which corresponds to a condition of few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good, equivalent to stable banks along 75 to 90% of the stream. Streambank stability was rated fair.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road densities in the watersheds of streams 15.0348 and 15.0349 were 3.2 and 5.2 miles per square mile respectively (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor for both watersheds.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) for the Shipbuilders Creek Watershed are indicative of a riparian buffer that has been impacted by some encroachment (i.e. moderate buffer width), comprised of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

<u>Water Quality</u>

Temperature

No information was available. Kitsap PUD will be monitoring water temperatures in 2003 (Labbe 2003, Personal communication).

Dissolved Oxygen

No information was available.

Hydrology

Flow-Hydrologic Maturity

No quantitative assessment has taken place. Much of each watershed was last logged in the late 1970s-early 1980s. A cursory examination of 1994 aerial photos showed that <60% of the forest cover was ≥25 years old in both watersheds (Todd 2003, Personal communication).

Flow-Percent Impervious Surfaces

No information was available.

Biological Processes

No information was available to assess biological processes.

Little Boston Creek (15.0350) Watershed

Description

Little Boston Creek enters Port Gamble Bay at Point Julia. The stream is 1.8 miles long with several tributaries. Stream 15.0351 enters the left bank of Little Boston Creek at RM 0.9. This stream is about 0.4 of a mile in length with several tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A weir at the fall chum hatchery at the mouth of Little Boston Creek is a complete barrier to anadromous fish. A culvert upstream at Little Boston Road is also a complete barrier (Todd 2003, Personal communication). Returning adult salmon are passed above the hatchery weir to spawn in the short reach below Little Boston Road (Labbe 2003, Personal communication). Artificial barriers were rated poor. See Map 25.

Floodplains

Floodplain Connectivity

Floodplain connectivity along the lower 100 meters of stream is reduced by a hatchery, artificial impoundments, and water supply pipeline. The stream flows through a confined ravine above this reach (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions fair, equivalent 25 to 50% of floodplain connectivity altered or lost. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

Little Boston Creek historically had only a small amount of floodplain habitat at the mouth and upstream about 100 meters. This habitat was lost to the hatchery facility (Todd 2003, Personal communication). Loss of floodplain habitat was rated poor.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment fair, equivalent to a fine sediment level of 15 to 20%. Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to poor.

Large Woody Debris

May and Peterson (2002) rated LWD abundance fair, which corresponds to sparse or infrequent abundance. Large woody debris abundance was rated poor.

Percent Pools

May and Peterson (2002) rated percent pools fair, which equates to 20 to 30% pool surface area. Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, which corresponds to a condition of few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good, equivalent to stable banks along 75 to 90% of the stream. Streambank stability was rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Little Boston Creek Watershed was 4.2 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) indicate a riparian buffer that has been impacted by some encroachment (i.e. moderate buffer width), comprised of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

Temperature

Summer water temperatures were measured in Little Boston Creek at Little Road in the summer of 2001. From July 1 through September 30, the annual instantaneous maximum temperature (AIMT) was 14.1°C. The 7-DADMT was 13.7°C. The 21-day average daily temperature was 12.7°C (Labbe *et al.* 2002). Temperature was rated good.

Dissolved Oxygen

No information was available.

Hydrology

No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

Middle Creek (15.0352) Watershed

Description

Middle Creek enters Port Gamble Bay about 0.9 of a mile south of Little Boston Creek. The stream is about 1.1 miles long (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at Little Boston Road (RM 0.1) is a complete barrier to anadromous fish (Todd 2003, Personal communication). Artificial barriers were rated poor. See Map 25.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good, with <25% loss of connectivity. Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% of habitat lost). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment fair, equivalent to a fine sediment level of 15 to 20%. Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to poor.

Large Woody Debris

May and Peterson (2002) rated LWD abundance fair, which corresponds to sparse or infrequent abundance. Large woody debris abundance was rated poor.

Percent Pools

May and Peterson (2002) rated percent pools fair, which equates to 20 to 30% pool surface area. Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, which corresponds to a condition of few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good, equivalent to stable banks along 75 to 90% of the stream. Streambank stability was rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Middle Creek Watershed was 2.2 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) equate to a riparian buffer that has been impacted by some encroachment (i.e. moderate buffer width), comprised of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

Water quality in Middle Creek is impacted by leachate from the Hansville Landfill, which is located upslope. Contaminants identified in the stream include: arsenic, vinyl chloride, and heavy metals (Labbe 2003, Personal communication).

Temperature

Summer water temperatures were monitored in Middle Creek at Little Boston Road in 1992-1994, and 2001. Annual instantaneous maximum temperatures (AIMT) were 15.0°C, 14.4°C, and 11.7°C in 1992, 1993, and 1994, respectively. In 2001 and 2002, the AIMT was 13.8°C. The seven-day average daily maximum temperature was 13.3°C. (Port Gamble S'Klallam Tribe 2003, Unpublished work). Inflow from numerous springs and a relatively intact riparian buffer maintain the relatively cool summer water temperatures (Labbe 2003, Personal communication). Temperature was rated good.

Dissolved Oxygen

No information was available.

Hydrology

No information was available to assess hydrology.

Biological Processes

No biological processes information was available.

Martha John Creek (15.0353) Watershed

Description

Martha John Creek (also known as Martha John-Miller Creek) enters Port Gamble Bay about 1.3 miles northeast of the mouth of Gamble Creek. The stream is about 2.4 miles in length and has several fish-bearing tributaries, including streams 15.0354 and 15.0355 (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Upstream from Miller Lake, the stream is fringed by wetlands along its entire length (Labbe 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert on Martha John Creek at 288th street can be a fish passage barrier at both high and low flows and may impact flow out of the Miller Lake wetland complex (May and Peterson 2002). Artificial barriers were rated fair. See Map 25.

Floodplains

Floodplain Connectivity

Wetlands provide ample off-channel habitat (May and Peterson 2002). Wetlands along the stream indicate that floodplains are functional. The road crossing at 288th Street causes backwatering. Beaver dams upstream appear to enhance this effect (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions good, with <10% loss of connectivity. Floodplain connectivity was rated good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<10% of habitat lost). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment levels on the lower half-mile of Martha John Creek and stream 15.0354 good, equivalent to fine sediment levels of 10 to 15%. Fine sediment levels from RM 0.5 to the headwaters of Martha John Creek were rated fair (15 to 20% fines). Wetlands fringe the entire length of the channel upstream from Miller Lake. Fine sediment levels would naturally be elevated in this low gradient reach (Labbe 2003, Personal communication). Fine sediment was rated good to fair on the lower half-mile of Martha John Creek and stream 15.0354, and fair from RM 0.5 upstream on Martha John Creek.

Large Woody Debris

May and Peterson (2002) rated LWD abundance fair on both Martha John Creek and stream 15.0354, which corresponds to sparse or infrequent abundance. Large woody debris abundance was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area good (30 to 40% pool surface area) on the entire mainstem of Martha John Creek and stream 15.0354. Percent pools were rated fair.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good on the lower half-mile of Martha John Creek and stream 15.0354. This rating corresponds to a condition of some deep pools with good cover. They rated pool quality optimal (frequent deep pools with cover) from RM 0.5 to the headwaters of Martha John Creek. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good on Martha John Creek, equivalent to stable banks along 75 to 90% of the stream, and optimal on stream 15.0354 (>90% stable banks). Streambank stability was rated fair on Martha John Creek, and good on stream 15.0354.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Martha John Creek Watershed was 2.1 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

Riparian Zones

Riparian Condition

Deciduous trees and second growth firs are the dominant vegetation in the riparian corridor of Martha John Creek. Some patches of mature conifers are present. Miller Lake has a wide, relatively intact coniferous riparian buffer (May and Peterson 2002). Riparian habitat ratings in May and Peterson (2002) indicate that from the mouth to RM 0.5 on the mainstem, the buffer is narrow and fragmented. From RM 0.5 to the headwaters and on stream 15.0354, the buffer is wide and intact. The buffer is comprised of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating for the lower half-mile of the mainstem was 2.7. The mean rating for the remainder of the mainstem and stream 15.0354 was 3.3. Riparian condition was rated fair to poor on the lower half-mile of the mainstem, and good to fair on the remainder of the mainstem and stream 15.0354.

Water Quality

Temperature

Summer water temperatures were monitored in Martha John Creek from 1992-1994 at NE 288th Street, and in 2001 about 0.5 miles downstream from NE 288th Street. The AIMT in 1992, 1993, and 1994 was 24.4°C, 21.1°C, and 21.7°C respectively. The AIMT in 2001 was 15.8°C, with a seven-day average daily maximum temperature of 15.3°C (Port Gamble S'Klallam Tribe 2003, Unpublished work). In 2002, water temperatures at the site downstream from NE 288th Street were comparable to those measured in 2001. Temperatures at the site downstream from NE 288th Street are more representative of conditions in the lower portion of Martha John Creek, the primary anadromous reach. Several spring-fed tributaries upstream from this site cool water temperatures. Conditions at NE 288th Street are influenced by a wetland. Water temperature was rated good on the lower reach and poor on the upper reach.

Dissolved Oxygen

No information was available.

Hydrology

Extensive headwater wetlands (including Miller Lake) and beaver ponds maintain stable stream flows (May and Peterson 2002). Twin culverts at the NE 288th Street Road crossing are frequently blocked by debris deposited by beavers in the spring and early summer. Kitsap County Public Works routinely removes this debris, unleashing a torrent of water downstream (equivalent to an out-of-season winter freshet). The effects on salmonids are unclear, but few juvenile salmonids have been observed during stream surveys conducted by three different biologists. This suggests that the rapid release of water stored upstream from NE 288th Street is flushing juvenile salmonids out of the stream (Labbe 2003, Personal communication). No information was available to assess hydrologic maturity of percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

Gamble Creek (15.0356) Watershed

Description

Gamble Creek enters saltwater at the southern terminus of Port Gamble Bay. The stream is about 4.6 miles long with several fish-bearing tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert on stream 15.0358 is a complete barrier. See Map 25. No other barriers are known to be present in the watershed, but a comprehensive culvert inventory is needed in the upper watershed (Todd 2003, Personal communication). May and Peterson (2002) rated artificial barriers good (<10% of watershed blocked). Artificial barriers were rated good based on the barrier noted above, but additional information is needed to assess conditions in the remainder of the watershed.

Floodplains

Floodplain Connectivity

Portions of Gamble Creek have been channelized from Bond Road (SR-307) to Stevens-Uhler Road. At least two meander reconstruction projects have taken place on this reach in the past five years (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions fair (25 to 50% of floodplain connectivity lost) on the lower mile of Gamble Creek and optimal (natural floodplain function) from RM 1.0 upstream. Floodplain connectivity was rated fair on the lower mile of stream, and good from RM 1.0 upstream.

Loss of Floodplain Habitat

Some floodplain habitat has been lost, but there are opportunities to reconnect off-channel habitats through meander reconstruction and floodplain restoration (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions fair (25 to 50% of floodplain habitat lost) on the lower mile of Gamble Creek and optimal (natural floodplain function) from RM 1.0 upstream. Loss of floodplain habitat was rated fair on the lower mile of stream, and good from RM 1.0 upstream.

<u>Channel Conditions</u>

Fine Sediment

Substrate embeddedness on two reaches of Gamble Creek (about 1 mile total length) ranged from 5 to 25% in the summer of 1990. Gravel was the dominant substrate on both reaches, while sand was subdominant (Point No Point Treaty Council 1990, Unpublished work). The lower mile of Gamble Creek is prone to fine sediment deposition, primarily sand and silt. Moderate storm events have been known to fill pools and smother riffles with fine sediment. The sources of this fine sediment are unknown, but development including forest clearing, grading, and road crossings likely contributes to the problem. Some fine sediment may be derived from bank erosion, or beaver ponds upstream. A large portion of banks on the lower reach are composed of sand and are prone to erosion (Todd 2003, Personal communication). May and Peterson (2002) rated fine sediment levels fair (15 to 20% fines) on the lower mile of Gamble Creek, and good (10 to 15% fines) from RM 1.0 upstream. Fine sediment was rated good to poor.

Large Woody Debris

Large woody debris total piece abundance in 1990 was 3.1 pieces per channel width on reach V4-1 and 2.7 pieces per channel width on reach M2-1 (Point No Point Treaty Council 1990, Unpublished work). Large woody debris was rated good.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools) on the lower mile of Gamble Creek, and optimal (40 to 60% pools) from RM 1.0 upstream. Percent pools were rated good to poor.

Pool Frequency

In 1990, pool frequency was 4.8 channel widths per pool on reach V4-1 and 4.6 channel widths per pool on reach M2-1 (Point No Point Treaty Council 1990, Unpublished work). Pool frequency was rated poor.

Pool Quality

Mean residual pool depth on about one mile of Gamble Creek ranged from 0.3 to 0.32 meters (about one foot deep) (Point No Point Treaty Council 1990, Unpublished work). May and Peterson (2002) rated pool quality fair on the lower mile of Gamble Creek, which corresponds to a condition of a few deep pools with little cover. They rated pool quality from RM 1.0 upstream optimal, equivalent to a condition of frequent deep pools with cover. Pool quality was rated fair on the lower mile of Gamble Creek and good from RM 1.0 upstream.

Streambank Stability

Banks along the lower portion of Gamble Creek contain a high percentage of sand and are susceptible to erosion (Todd 2003, Personal communication). May and Peterson (2002) rated streambank stability poor (<50% stable banks or riprap present) on the lower mile of Gamble Creek, and good (75 to 90% stable banks) from RM 1.0 upstream. Streambank stability was rated poor on the lower mile of Gamble Creek and fair from RM 1.0 upstream.

<u>Sediment Input</u>

Sediment Supply

See "Fine Sediment" above. Sediment supply was rated poor.

Mass Wasting

No information was available.

Road Density

Road density in the Gamble Creek Watershed was 3.5 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

In 1990, the riparian buffer along reach V4-1 was composed of 60% deciduous vegetation, and 40% mixed deciduous and coniferous plants. Clearcut and shrubs were the dominant seral stages on this reach (64.6%). Oldgrowth and mature forest comprised roughly 10% and 19% of the buffer respectively. The buffer along reach M2-1 was composed of 65% mixed deciduous and coniferous vegetation, 27% deciduous stands, and 8% coniferous stands. Mature forest and shrubs were co-dominant, each comprising 38% of the riparian buffer. Young vegetation was present in 22% of the buffer, while oldgrowth forest was present in 2% of the buffer (Point No Point Treaty Council 1990, Unpublished work). Riparian buffer ratings in May and Peterson (2002) on the lower mile of Gamble Creek equate to a buffer impacted by frequent encroachment, composed of shrubs and brush with little to no forest. Grasses and shrubs, and/or invasive plants are the dominant vegetation. Conditions improve substantially upstream from RM 1.0 where ratings indicate a wide and intact buffer composed of mature coniferous trees. Riparian condition was rated poor from the mouth to RM 1.0, and good from RM 1.0 upstream.

Water Quality

Temperature

Summer water temperatures in Gamble Creek were measured in 1992-1994, 1996, and 2001. The AIMT in lower Gamble Creek at Bond Road/State Route 307 was 19.4°C, 20.0°C, and 21.1°C in 1992, 1993, and 1994 respectively. In 1996, the AIMT was 18.5°C. The seven-day average daily maximum temperature was 18.1°C with a 21-day average daily temperature of 15.8°C. In 2001, the AIMT was 18.8°C. The seven-day average daily maximum temperature was 18.0°C, with a 21-day average daily temperature of 15.1°C (Labbe *et al.* 2002). Temperatures were measured in 1996 at Stevens-Uhler Road. The AIMT was 19.8°C. The seven-day average daily maximum temperature was 19.0°C, with a 21-day average daily temperature of 16.1°C. Temperatures in upper Gamble Creek were measured at Rova Road in 1996 and 2001. The AIMT was 13.6°C and 13.4°C in 1996 and 2001 respectively. The seven-day average daily maximum temperature was 13.4°C and 13.0°C in 1996 and 2001 respectively. The 21-day average daily temperature was 12.1°C and 12.3°C in 1996 and 2001 respectively. Summer 1996 temperatures in Gamble Creek at Iverson Road were nearly identical to those at Rova Road in 1996 (Labbe *et al.* 2002). Degraded riparian conditions from RM 1.0 downstream contribute to high summer water temperatures. Riparian conditions upstream from RM 1.0 are substantially better, maintaining cool summer water temperatures (Labbe 2003, Personal communication). Temperature was rated poor from Stevens-Uhler Road downstream and good from Rova Road upstream.

Dissolved Oxygen

No information was available.

Hydrology

No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

Todhunter Creek (15.0360) Watershed

Description

Todhunter Creek enters Port Gamble Bay about 0.8 of a mile northwest of the mouth of Gamble Creek. The stream is about 1.4 miles in length with several small tributaries.

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert under SR 104 is a partial barrier to anadromous fish. A pipe draining an artificial impoundment is a complete barrier just upstream from the highway. The pipe barrier and a suspected water diversion to a plant nursery need further investigation (Todd 2003, Personal communication). A culvert just upstream from SR 104 is a complete barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair, which corresponds to 25 to 50% of floodplain area altered or lost. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions fair, which corresponds to 25 to 50% of floodplain area altered or lost. Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment levels good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated good to fair.

Large Woody Debris

May and Peterson (2002) rated LWD quantity fair, which corresponds to sparse abundance. Large woody debris abundance was rated poor.

Percent Pools

May and Peterson (2002) rated pool surface area fair, equivalent to 20 to 30% pool surface area. Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, which corresponds to a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Todhunter Creek Watershed was 3.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) indicate that the riparian buffer is narrow and fragmented, and comprised of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 2.7. Riparian condition was rated fair to poor.

<u>Water Quality</u>

No water quality information was available.

<u>Hydrology</u>

A suspected water diversion and artificial impoundment just upstream from SR 104 merit further investigation (Todd 2003, Personal communication). No information was available to assess hydrologic maturity or percent impervious surfaces.

<u>Biological Processes</u>

No biological processes information was available.

Ladine DeCouteau Creek (Unnumbered) Watershed

Description

Ladine DeCouteau Creek enters the west shore of Port Gamble Bay about 0.9 of a mile south of the community of Port Gamble. The stream is about 0.4 of a mile long with a small tributary. Williams *et al.* (1975) did not map this stream.

Habitat Ratings

Access and Passage

Artificial Barriers

At least two barrier culverts are present on logging road #G1100 in the Ladine DeCouteau Creek Watershed. A culvert on the south branch is likely a partial barrier because of velocity. A perched culvert (2 ft. drop) on the west branch is a complete barrier. The extent to which these culverts block fish habitat is unknown. A more complete inventory of culverts and fish use is needed in this watershed (Todd 2003, Personal communication). See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity). Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat). Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment levels good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated good to fair.

Large Woody Debris

May and Peterson (2002) rated LWD quantity fair, which is equivalent to sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency
No information was available.

Pool Quality
May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability
May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input
No information was available to assess sediment supply or mass wasting.

Road Density
Road density in the Ladine DeCouteau Creek Watershed was 2.3 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003).

Riparian Zones

Riparian Condition
Riparian habitat ratings in May and Peterson (2002) indicate that the riparian buffer along Ladine DeCouteau Creek is narrow and fragmented, and comprised of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 2.7. Riparian condition was rated fair to poor.

Water Quality
No information was available to assess water quality conditions.

Hydrology

Flow-Hydrologic Maturity
A cursory examination of aerial photos showed that <60% of the watershed has vegetation ≥25 years old (Todd 2003, Personal communication). Hydrologic maturity is suspected to be poor.

Flow-Percent Impervious Surfaces
No information was available.

Biological Processes
No biological processes information was available.

Machias Creek (Unnumbered) Watershed

Description

Machias Creek enters Hood Canal about 0.2 of a mile west of the community of Port Gamble. The stream is 1.2 miles in length, about 0.4 of a mile of which are presumed to support salmonids. Williams *et al.* (1975) did not map this stream.

Habitat Ratings

Access and Passage

Artificial Barriers

A dam near the mouth is a partial barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). It is not known what the dam is used for. Trout fry have been observed upstream of the dam (Todd 2003, Personal communication). Another dam located at RM 0.7 is a complete barrier. See Map 25. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

Floodplain habitat is limited to a small area near the mouth of Machias Creek (Todd 2003, Personal communication). Floodplain connectivity was not rated.

Loss of Floodplain Habitat

Not applicable.

Channel Conditions

Fine Sediment

Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). No information was available to assess large woody debris, percent pools, pool frequency, pool quality, or streambank stability.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Machias Creek Watershed was 1.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated good.

Riparian Zones

Riparian Condition
No information was available.

Water Quality
No information was available to assess water quality conditions.

Hydrology
No hydrology information was available.

Biological Processes
No information was available to assess biological processes.

Spring Creek (15.0364) Watershed

Description
Spring Creek enters Hood Canal about 1.4 miles southwest of the Hood Canal Floating Bridge. The stream is about one mile long with a substantial network of tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers
A culvert at RM 0.1 was a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). This culvert was replaced several years ago and is no longer a barrier. Coho have been observed spawning upstream. A culvert upstream under State Route 3 is a complete barrier at all flows (Labbe 2003, Personal communication). See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity
May and Peterson (2002) rated floodplain conditions fair, with 25 to 50% lost connectivity. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat
May and Peterson (2002) rated floodplain conditions fair, with 25 to 50% lost floodplain habitat. Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment levels good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated good to fair.

Large Woody Debris

May and Peterson (2002) rated LWD quantity fair, which is equivalent to sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Spring Creek Watershed was 4.6 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003).

Riparian Zones

Riparian Condition

Much of the native riparian vegetation along the left bank of the lower 175 meters of stream has been converted to landscaping. There may be an opportunity to improve riparian conditions on this reach (Todd 2003, Personal communication). Riparian habitat ratings from May and Peterson (2002) indicate that the riparian buffer along Spring Creek is of moderate width with some encroachment from development. The buffer is comprised of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.0. Riparian condition was rated fair.

Water Quality

Temperature

Water temperatures were monitored at Scenic View Drive in the summers of 1992-1994. The AIMT was 13.3°C, 14.4°C, and 12.8°C in 1992, 1993, and 1994 respectively (Labbe *et al.* 2002). Water temperature was rated good.

Dissolved Oxygen

No information was available.

Hydrology

An extensive network of headwater springs maintains remarkably stable flows in Spring Creek. The stream maintains stable flows and remains gin clear even after heavy winter storms (Labbe 2003, Personal communication). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

Cougar Creek (15.0367) and Kinman Creek (15.0368) Watershed

Description

Kinman Creek enters Hood Canal about 0.5 of a mile northeast of the community of Lofall. The stream is about 2.6 miles long with several tributaries, including Cougar Creek, which enters the right bank of Kinman Creek at RM 0.3 (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Kinman Creek originates from springs in Big Valley, an area dominated by agricultural and rural residential land use (Todd 2003). Cougar Creek originates at a small lake/wetland complex and is 2.3 miles long with several tributaries (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert under the State Route 3 crossing of Kinman Creek is a partial barrier because of a steep slope. A dam at the Manor Farm pond is a complete barrier in the upper watershed (Todd 2003, Personal communication). A comprehensive barrier inventory has not been conducted, but additional barriers are likely to be present because of extensive rural residential development (Labbe 2003, Personal communication). See Map 25. Artificial barriers were rated fair to poor.

Floodplains

Floodplain Connectivity

Filling and channelization have reduced floodplain connectivity from approximately RM 0.8 downstream. The fill and channel modifications limit development of off-channel habitat. A sizable reach of Kinman Creek located near the headwaters has been channelized (Todd 2003, Personal communication). May and Peterson (2002) rated floodplain conditions on Cougar Creek fair (25 to 50% lost connectivity) and good on Kinman Creek (<25% lost connectivity). Floodplain connectivity was rated fair on Cougar Creek and fair to good on Kinman Creek.

Loss of Floodplain Habitat

Less than 33% of floodplains in the Kinman Creek Watershed have been lost (Todd 2003, Personal communication). Floodplain habitat along the lower 575 feet of Kinman Creek was lost to filling and home development. A salt marsh 1 to 1.6 acres in size was historically present at the mouth of the stream, but residential development at the site filled much of the salt marsh and constricted the stream channel. Tidal inflow was reduced by the fill and channelization activities, converting the remaining marsh to a brackish or freshwater wetland habitat (Todd 2003). Floodplain constrictions occur at and upstream of the Kinman Road crossing and the State Route 3 crossing on Kinman Creek. The extent of lost floodplain habitat upstream from the State Route 3 crossing has not been assessed, but there may be opportunities to restore habitat lost to channelization in the Big Valley reach. A series of simulated "beaver ponds" was constructed in the left bank tributary of Kinman Creek just upstream from tidal influence during a summer 2002 restoration project. The ponds are intended to provide rearing habitat for cutthroat trout and coho salmon (Todd 2003). A vast spruce-alder wetland complex historically spanned the divide between the headwaters of Kinman Creek and North Fork Dogfish Creek to the east. Clearing, drainage, agricultural and residential development have vastly reduced the size and quality of this wetland (Labbe 2003, Personal communication). May and Peterson (2002) rated floodplain conditions on Cougar Creek fair (25 to 50% lost floodplain habitat) and good on Kinman Creek (<25% lost floodplain habitat). Loss of floodplain habitat was rated fair in both watersheds.

Channel Conditions

Fine Sediment

May and Peterson (2002) reported occasional occurrences of high turbidity in Kinman Creek. They rated fine sediment good (10 to 15% fines) on Cougar Creek and fair (15 to 20% fines) on Kinman Creek. Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to good on Cougar Creek, and fair to poor on Kinman Creek.

Large Woody Debris

In the summer of 2002, LWD abundance was 0.11 pieces per meter on the lower 0.8 kilometer of Kinman Creek. Few key pieces were noted (May and Peterson 2002). Todd

(2003) reported 0.39 pieces per channel width, and 0.01 key pieces per channel width from analysis of the summer of 2002 data. Woody debris is lacking in abundance and the majority of LWD is derived from deciduous vegetation. Woody debris recruitment potential was characterized as poor because of low coniferous tree abundance in the riparian zone (May and Peterson 2002). About 100 meters (~330 feet) of lower Kinman Creek were enhanced in the summer of 2002 through placement of about 20 pieces of large woody debris. Although conditions were enhanced on this small reach, LWD abundance is severely limited on the remainder of the lower 0.8 mile of Kinman Creek (Todd 2003). Large woody debris abundance was rated poor.

Percent Pools

Pools comprised 25% of surface area in the summer of 2002 on the lower 0.8 kilometer of Kinman Creek (May and Peterson 2002). May and Peterson (2002) rated percent pools good (30 to 40% pools) throughout the Cougar-Kinman Creek Watershed. Percent pools were rated fair to poor.

Pool Frequency

Pool frequency in the summer of 2002 on Kinman Creek was seven channel widths per pool (Todd 2003). Pool frequency was rated poor.

Pool Quality

In the summer of 2002, mean residual pool depth on the lower 0.8 kilometer of Kinman Creek was 0.4 meter (May and Peterson 2002). May and Peterson (2002) rated pool quality good (some deep pools with cover) throughout the Cougar-Kinman Creek Watershed. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good on Cougar Creek (75 to 90% stable banks), and fair on Kinman Creek (50 to 75% stable banks). Streambank stability was rated fair on Cougar Creek and poor on Kinman Creek.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Cougar & Kinman Creeks Watershed was 3.6 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Rural residential development that encroaches on the riparian buffer is commonplace on Kinman Creek between State Route 3 and Big Valley Road. Deciduous trees are the dominant vegetation in riparian stands. Some reaches lack forested buffers (May and Peterson 2002). Invasive plants including English Ivy, Japanese knotweed, and

Himalayan blackberry are present in the riparian zone (Todd 2003). Riparian habitat ratings from May and Peterson (2002) indicate that the Cougar Creek riparian buffer is of moderate width with some encroachment from development. The buffer is comprised of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.0. Riparian habitat ratings from May and Peterson (2002) correspond to a riparian buffer on Kinman Creek that is narrow and fragmented from development. The buffer is composed of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 2.7. Riparian condition was rated fair on Cougar Creek and fair to poor on Kinman Creek.

Water Quality

Temperature

Summer water temperatures were measured in Kinman Creek at the Kinman Road crossing in 1992-1994 and 2001. The AIMT was 15.6°C, 13.3°C, 12.8°C, and 15.1°C in 1992, 1993, 1994, and 2001 respectively. The seven-day average daily maximum temperature in 2001 was 13.7°C, with a 21-day average daily temperature of 12.5°C (Labbe *et al.* 2002). Temperature was rated good to fair.

Dissolved Oxygen

No information was available.

Hydrology

No hydrology information was available.

Biological Processes

No information was available to assess biological processes.

Jump Off Joe Creek (15.0369) Watershed

Description

Jump Off Joe Creek enters Hood Canal about 0.9 of a mile southwest of the community of Lofall. The stream is 1.7 miles long with several small tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

Culverts at Pioneer Way (RM 0.8) and a private road upstream (RM 1.0) are both complete barriers to anadromous fish. The culvert at Pioneer Way is perched several feet above the channel and buried under more than 50 feet of fill. The culvert is more than

100 feet long. Fish presence above and below these barriers should be investigated (Todd 2003, Personal communication). See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

The lower 125 meters of stream have been straightened and armored. The channel may have been relocated during construction of a residential development. Above this reach, the stream flows through a confined ravine where floodplains are naturally limited (Todd 2003, Personal communication). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Floodplain habitat along the lower 125 meters of stream was lost to residential development (Todd 2003, Personal communication). Loss of floodplain habitat was rated poor.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to good.

Large Woody Debris

Approximately 50 pieces of LWD were counted in the lower 0.35 miles of stream. The vast majority of wood was small and medium size alder (Todd 2003, Personal communication). May and Peterson (2002) rated LWD abundance fair, corresponding to sparse abundance. Large woody debris abundance was rated poor.

Percent Pools

Pools are uncommon in the lower 0.35 miles of stream (Todd 2003, Personal communication). May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, corresponding to a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability poor, equivalent to <50% stable banks or riprap along banks. Streambank stability was rated poor.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Jump Off Joe Creek Watershed was 3.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) are indicative of a narrow riparian buffer fragmented by development. The buffer is composed of a mix of mature and immature deciduous trees. The mean riparian condition rating was 2.3. Riparian condition was rated fair to poor.

Water Quality

No water quality information was available.

Hydrology

No information was available to assess hydrology.

Biological Processes

No biological processes information was available.

Cattail Creek (15.0374) Watershed

Description

Cattail Creek is located on the Bangor U.S. Naval Reservation and enters Hood Canal about 0.4 of a mile southwest of the community of Vinland. The stream is about 1.6 miles in length (Williams *et al.* 1975). The Cattail Creek Watershed is the least developed watershed on the Bangor Naval Station. With the exception of a road fill at the outlet of Cattail Lake, the stream and its tributaries have been relatively unaffected by human activities. The stream originates off the Naval Station near the community of Vinland, an area experiencing a significant amount of residential development. Cattail Creek has the potential to support both anadromous and resident salmonid production with diverse instream and off-channel habitats. Salmonid habitat was described as generally high quality. However, anadromous fish have not had access to the stream since the construction of Cattail Lake was completed (May 1997).

Habitat Ratings

Access and Passage

Artificial Barriers

A road fill at the outlet of Cattail Lake has no fish ladder and is a complete barrier to anadromous fish (May 1997). See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity). Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

A high quality wetland at the inlet of Cattail Lake would provide quality coho rearing habitat (May 1997). May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat). Loss of floodplain habitat was rated fair.

Channel Conditions

The middle and upper reaches of Cattail Creek have excellent spawning habitat and adequate rearing habitat (May 1997).

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to good.

Large Woody Debris

LWD levels were described as adequate with generally good recruitment potential throughout the mainstem (May 1997). May and Peterson (2002) rated LWD quantity fair, equivalent to sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

<u>Sediment Input</u>

Sediment Supply

No information was available.

Mass Wasting

Several landslides were noted along Cattail Creek, but this is typical of the highly confined channels draining to Hood Canal (May 1997). Mass wasting was rated good.

Road Density

Road density in the Cattail Creek Watershed was 0.1 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated good.

<u>Riparian Zones</u>

Riparian Condition

The riparian buffer is predominantly mature coniferous forest (May 1997). Riparian habitat ratings in May and Peterson (2002) indicate a wide and intact riparian buffer composed of mature coniferous trees. The mean riparian condition rating was 4.0. Riparian condition was rated good.

<u>Water Quality</u>

No water quality information was available.

Hydrology
No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

Nutrients
A complete barrier at the mouth of Cattail Lake prevents anadromous fish access (May 1997). Nutrients were rated poor.

Biological Diversity
Exotic warm water fish have been introduced to Cattail Lake (Todd 2003, Personal communication). Biological diversity was rated poor.

Devils Hole Creek (15.0374) and Unnamed Streams 15.0371-0373 Watershed

Description
The Devils Hole Creek Watershed is located entirely within the west-central portion of the Bangor Naval Station. The lower portion of Devils Hole Creek is relatively unimpacted until it enters Devils Hole Lake. The lake is a man-made impoundment similar to Cattail Lake. In contrast to Cattail Lake, a fish ladder at the outlet of Devils Hole Lake allows migration of anadromous fish. The mainstem of Devils Hole Creek, Devils Hole Lake, and a wetland at the lake inlet provide complex instream salmonid habitat (May 1997). Devils Hole Creek enters Hood Canal about 1.5 miles northwest of the community of Bangor. The stream is 1.5 miles in length with one sizeable right bank tributary. Unnamed Stream 15.0373 enters Hood Canal about 0.2 of a mile northeast of Devils Hole Creek. The stream is about 0.9 of a mile in length. Unnamed Stream 15.0372 enters Hood Canal about 0.65 miles northeast of Stream 15.0373. The stream is about 0.6 of mile long. Stream 15.0371 enters Hood Canal about 0.6 of a mile northeast of Stream 15.0372 (Williams *et al.* 1975). The stream is 1.5 miles long, but only a small reach near the mouth is known to produce salmonids (TAG 2003).

Habitat Ratings

Access and Passage

Artificial Barriers
The dam at the outlet of Devils Hole Lake is a partial barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). A fish ladder is present at this dam (May 1997). Three culverts on stream 15.0374A are complete barriers. See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity) on Devils Hole Creek. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

A wetland at the inlet to Devils Hole Lake provides quality coho rearing habitat (May 1997). May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat). Loss of floodplain habitat was rated fair.

Channel Conditions

Devils Hole Creek provides adequate spawning and rearing habitat (May 1997).

Fine Sediment

Fine sediment levels appeared to be elevated, possibly from development in the upper portions of the watershed (May 1997). May and Peterson (2002) rated fine sediment good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to good.

Large Woody Debris

The mainstem has adequate LWD. Woody debris recruitment potential was described as "good" throughout the mainstem (May 1997). May and Peterson (2002) rated LWD quantity fair, equivalent to sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area good (30 to 40% pools). Percent pools were rated fair.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input

Sediment Supply

No information was available.

Mass Wasting

Several landslides were noted along the stream, but this is natural in the highly confined streams on Hood Canal (May 1997). Mass wasting was rated good.

Road Density

Road density in the Devils Hole Creek Watershed was 1.6 miles per square mile. Road densities in the watersheds of streams 15.0371, 15.0372, and 15.0373 were 3.7, 8.0, and 2.4 miles per square mile respectively (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated good to poor.

Riparian Zones

Riparian Condition

The riparian buffer on Devils Hole Creek was described as generally "excellent," and composed of predominantly mature coniferous forest (May 1997). Riparian habitat ratings in May and Peterson (2002) indicate a riparian buffer somewhat impacted by development, but composed of mature coniferous trees. The mean riparian condition rating was 3.7. Riparian condition was rated good to fair.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

Unnamed Stream 15.0376 Watershed

Description

Unnamed Stream 15.0376 (locally known as Farm Road Creek) enters Hood Canal about 0.6 of a mile south of the community of Olympic View. The stream is about 1.2 miles long with several tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No fish passage barriers are known to be present in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 25. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity). Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat). Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Most streams in this subbasin have high fine sediment levels, likely the result of past watershed disturbances and naturally low flows which limit flushing of fines (Labbe 2003, Personal communication). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity fair, equivalent to sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Stream 15.0376 Watershed was 2.2 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) are indicative of a narrow and fragmented buffer composed of a mixed forest of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 2.7. Riparian condition was rated fair to poor.

Water Quality

No information was available to assess water quality conditions.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

BIG BEEF-ANDERSON SUBBASIN HABITAT LIMITING FACTORS

Subbasin Description

The Big Beef-Anderson Subbasin drains 66 square miles of land from the northern boundary of the Little Anderson Creek Watershed near Olympic View south to the southern boundaries of the Anderson and Thomas Creek Watersheds near Holly. See Map 4. Little Anderson, Big Beef, Seabeck, Stavis, Boyce, Harding, and Anderson Creeks are the largest streams within this subbasin. Residential developments are concentrated at the communities of Seabeck and Holly, as well as the headwaters of Little Anderson Creek and the shoreline of Lake Symington in the middle portion of the Big Beef Creek Watershed. Descriptions of individual watersheds are located in the habitat description of each stream.

Little Anderson Creek (15.0377) Watershed

Description

Little Anderson Creek enters Hood Canal about 1.5 miles northeast of Big Beef Harbor. The stream has an extensive network of tributaries (Williams *et al.* 1975) as well as numerous wetlands (Hood Canal Coordinating Council 2002). Little Anderson Creek is close to Silverdale, the commercial center of the Kitsap Peninsula. Anderson Hill and Newberry Hill Roads bisect the watershed, making it accessible for residential development. Suburban development presently exists in the headwaters of the watershed (May 1996).

Habitat Ratings

Access and Passage

Artificial Barriers

Two culverts under Anderson Hill Road were complete barriers (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 25. The culvert on the mainstem susceptible to blockage with sediment and debris and blocked fish passage several times during the early to mid-1990s (May 1996). This culvert was replaced in 2002. The culvert at the Anderson Hill Road crossing of stream 15.0379 is still a complete barrier (TAG 2003). A culvert on Little Anderson Creek at Newberry Hill Road is greater than 75' long and may pose a velocity barrier to adult salmonids (Washington Department of Natural Resources 1995). This culvert is a partial barrier. Coho fry have been observed above the culvert (Labbe 2003, Personal communication). Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

May and Peterson rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

The mainstem is particularly lacking in large woody debris, reducing the amount of salmonid rearing habitat (May 1996). In the mid-1990s, woody debris abundance ranged from 0.108 pieces per meter on the lower reach to 0.283 pieces per meter on the upper reach of mainstem Little Anderson Creek. The non-weighted mean was 0.190 pieces/m. Coniferous trees comprised a non-weighted mean of 69% of the LWD inventoried. A non-weighted mean of 31% of wood inventoried was larger than 0.5 meter in diameter. Stream 15.0378 had 0.089 pieces of wood per meter. Fifty-six percent of the wood was coniferous, and 18% was greater than 0.5 meter in diameter. Stream 15.0379 had 0.091 pieces of wood per meter. Sixty-nine percent of the wood was coniferous and 24% was greater than 0.5 meter in diameter. Stream 15.0382 had 0.378 pieces of LWD per meter. Coniferous vegetation comprised 70% of the wood inventoried. Thirty-one percent of the wood was larger than 0.5 meter in diameter (May and Peterson 2002). Large woody debris was rated poor.

Percent Pools

Mainstem Little Anderson Creek had a percent pool composition range from 5 to 24% in the mid-1990s. The non-weighted mean was 15.7%. Stream 15.0378 had a pool surface area of 26%. Stream 15.0379 had 19% pool surface area. Percent pool surface area was 30% on stream 15.0382 (May and Peterson 2002). Percent pools were rated poor.

Pool Frequency

In the mid-1990s, pool frequency on Little Anderson Creek ranged from a low of 18.3 channel widths per pool to a high of 5.3 channel widths per pool. The non-weighted mean pool frequency was 9.7 channel widths per pool. Stream 15.0378 had 12.5 channel widths per pool. Pool frequency on stream 15.0379 was 5.7 channel widths per pool. Stream 15.0382 had a pool frequency of 5.2 channel widths per pool (May and Peterson 2002). Pool frequency was rated poor.

Pool Quality

No pools greater than one meter deep were observed during mid-1990s surveys of Little Anderson Creek. Mean residual pool depth was 0.31 meter (May and Peterson 2002). May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair to poor.

Streambank Stability

May and Peterson (2002) rated streambank stability fair (50 to 75% stable banks) from the mouth to RM 0.5. Bank stability was rated good (75 to 90% stable banks) from RM 0.5 to RM 1.0. Bank stability upstream from RM 1.0 was rated optimal (>90% stable banks). Streambank stability was rated poor on the lower half-mile of stream, fair from RM 0.5 to RM 1.0, and good from RM 1.0 upstream.

<u>Sediment Input</u>

Sediment Supply

Logging and land clearing have contributed fine sediment to the stream (May 1996). The natural background sediment production rate for the Little Anderson Creek Watershed is 85 tons per year (Washington Department of Natural Resources 1995). The streambed has aggraded substantially downstream from the Seabeck Highway. In the past, the adjacent property owner annually cleared the channel with a bulldozer (Small 2003, Personal communication). Sediment supply was rated poor.

Mass Wasting

No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density

Road density in the Little Anderson Creek Watershed was 4.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

In the early 1990s, 74% of the riparian buffer on Little Anderson Creek provided >90% canopy closure. The remaining 26% provided 70 to 90% canopy closure (Washington Department of Natural Resources 1995). Upstream from Anderson Hill Road, the riparian zone is composed of mature conifers and has been identified by Kitsap County for possible protection. Below Anderson Hill Road, the stream flows through county park property (May 1996). Riparian habitat ratings in May and Peterson (2002) indicate a riparian buffer composed of a mix of mature and immature coniferous and deciduous trees. From the mouth to RM 0.5, the buffer is of moderate width with some encroachment from development. From RM 0.5 to RM 1.0, the buffer is narrow and fragmented by development. From RM 1.0 upstream the buffer is wide and intact.

Riparian condition was rated fair to poor on the middle reach, and fair on the lower and upper reaches.

Water Quality

Temperature

The maximum water temperature recorded from early August to early October 1992 was 13.9ºC (Bahls 1993, cited in Washington Department of Natural Resources 1995). Summer water temperatures were measured at the Anderson Hill Road crossing in 1992-1994. The AIMT was 13.9°C, 12.2°C, and 12.8°C in 1992, 1993, and 1994 respectively. Temperatures were monitored at Anderson Landing Road in 2001 and 2002. The AIMT was 14.0°C in 2001 and 15.1°C in 2002. The seven-day average daily maximum temperature was 13.8°C in 2001 and 14.6°C in 2002 (Port Gamble S'Klallam Tribe 2003, Unpublished work). Temperature was rated good.

Dissolved Oxygen

No information was available.

Hydrology

Flow-Hydrologic Maturity

Logging and land clearing have caused an altered hydrologic regime (May 1996). Hydrologic maturity was rated poor.

Flow-Percent Impervious Surfaces

In 1995, impervious surfaces covered 9.2% of the Little Anderson Creek Watershed. Impervious surface coverage was predicted to reach 15.6% in the future (Washington Department of Natural Resources 1995). May *et al.* (1997) reported only 3.4% total impervious area in the Little Anderson Creek Watershed. Percent impervious surfaces were rated fair.

Biological Processes

No information was available to assess biological processes.

Johnson Creek (15.0387) Watershed

Description

Johnson Creek enters Hood Canal about 0.7 of a mile northeast of Big Beef Harbor. The stream is about 1.3 miles long with one small tributary (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at RM 0.3 is a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 25. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity). Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat). Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity fair, indicating sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, indicating a condition of a few deep pools with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability poor (<50% stable banks or banks lined with riprap). Streambank stability was rated poor.

Sediment Input

Sediment Supply

No information was available.

Mass Wasting

No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density

Road density in the Johnson Creek Watershed was 8.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) are indicative of a narrow and fragmented riparian buffer comprised of a mix of immature and mature deciduous trees. Riparian condition was rated fair to poor.

Water Quality

No information was available to assess water quality conditions. The Port Gamble S'Klallam Tribe will be monitoring water temperatures during the summer of 2003 (Labbe 2003, Personal communication).

Hydrology

Flow-Hydrologic Maturity

No information was available.

Flow-Percent Impervious Surfaces

As of 1995, impervious surfaces covered 7% of the Johnson Creek Watershed. Impervious surface coverage was projected to expand to 19.5% in the future (Washington Department of Natural Resources 1995). Percent impervious surfaces were rated fair.

Biological Processes

No information was available to assess biological processes.

Big Beef Creek (15.0389) Watershed

Description

Big Beef Creek is located about two miles northeast of the town of Seabeck. The stream drains about 14 square miles. The mainstem is 11 miles long with 24 miles of tributaries (Ames *et al.* 2000). Big Beef Creek is the largest stream in the Big Beef-Anderson Subbasin. The stream originates in the central Tahuya Peninsula at about 500-feet elevation. The Tahuya River begins in the same marsh and drains to the south. During certain flow conditions the drainages are connected (Williams *et al.* 1975). The upper watershed is composed of low gradient channels associated with several wetlands, including Morgan Marsh. Lake Symington was constructed at RM 5.3 in 1964 as a residential development. From RM 5.3 downstream the stream flows through a steep, moderately confined ravine. From RM 2.0 to the mouth, the valley widens and gradient drops to less than one percent. Floodplain and complex side channel habitat are present on this reach. The estuary encompasses about 48 acres within a semi-enclosed lagoon (Ames *et al.* 2000).

Similar to Stavis and Seabeck Creeks, a shallow perched aquifer supplies the majority of base flow to Big Beef Creek. The Seabeck Aquifer, a deep aquifer, supplies additional flow near the mouth (Ames *et al.* 2000). The entire watershed from RM 5.0 upstream was logged between 1920 and 1950 (Amato 1996). Agriculture is practiced in several areas of the upper watershed. Since 1970, residential development has expanded, particularly around Lake Symington and the area just downstream (Ames *et al.* 2000). However, the reach from Lake Symington to the fish hatchery has experienced relatively little impact from residential development and is highly productive (May 1996). Most homes along in this reach are built on the glacial till plain above the stream (Ames *et al.* 2000). Unfortunately, releases of very warm surface water from Lake Symington severely impact salmonid habitat downstream (May 1996, May and Peterson 2002, Labbe *et al.* 2002, Port Gamble S'Klallam Tribe 2003, Unpublished work). This is a major limiting factor of salmonid production since the lower five miles of stream are the primary spawning and rearing areas within the watershed (TAG 2003).

The reach upstream from Lake Symington has been more heavily impacted by development than any other portion of the Big Beef Watershed (May 1996). In the past, water levels in Lake Symington were managed primarily for the benefit of lakeside residents with little regard for the effects on fish habitat downstream. Recently, WDFW amended the provisions of the lake's rules of operation to protect the flow requirements of fish habitat downstream. The University of Washington fisheries research facility is located between the mouth and RM 0.8. A weir is operated at RM 0.1 to count migrating coho salmon. The Hood Canal Salmon Sanctuary program has been purchasing key riparian habitat upstream from the UW research facility (Ames *et al.* 2000).

Habitat Ratings

Access and Passage

Artificial Barriers

A weir at RM 0.1 is a complete barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). The weir is used to count migrating coho salmon. Adult salmonids are passed over the weir to continue upstream (Ames *et al.* 2000). No other barriers are known to be present in the watershed. See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

From RM 2.0 to the mouth the valley widens and gradient drops to less than one percent. Floodplain and complex side channel habitat are present on this reach (Ames *et al.* 2000). Several incidents of channel modification occurred in the 1950s (Amato 1996). The UW channelized nearly 2,000 feet of the lower stream in 1969 because of concerns with extreme aggradation and potential reduced survival of summer chum (Cederholm 1972, cited in Ames *et al.* 2000). Gravel dikes were built along the southwest streambank, further constricting the floodplain and contributing additional sediment to the channel. The channelization attempts proved largely futile in addressing the aggradation and channel instability of the lower portion of Big Beef Creek. Spot dredging of the area upstream from the weir has taken place since the 1970s. The spoils have been disposed of on the Seabeck Road bridge causeway and a floodplain service road. Diking, road construction, filling, and alteration of side channel habitat (all associated with operation of the Big Beef Research Station) have reduced channel complexity of the lower two miles of Big Beef Creek (Ames *et al.* 2000). Floodplain connectivity was rated fair.

Loss of Floodplain Habitat

Many of the wetlands in the headwaters of Big Beef Creek have been modified to some extent by dredging, livestock production, vegetation clearing, and residential development. Although modifications have taken place, the wetlands still appear to provide quality habitat (Washington Department of Natural Resources 1995). Stream channelization, wetland drainage, and residential development adjacent to headwater wetlands have reduced coho rearing habitat (May 1996). Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

Cederholm (1972, cited in Ames *et al.* 2000) documented a 58% loss of summer chum redds because of scour, fill, and channel shifting. Average survival to emergence was only 9.4%. Substrate embeddedness of the study area was 16.3% (Ames *et al.* 2000). Kidhaven road was constructed down a small ephemeral stream channel that is prone to washout. This area produces large amounts of sediment and bank instability (May 1996).

May and Peterson (2002) rated fine sediment levels good (10 to 15% fines) throughout the flowing portions of Big Beef Creek. Fine sediment was rated fair to good.

Large Woody Debris

Channel modifications and aggradation have simplified instream habitat in lower Big Beef Creek. From 1993 to 1994, large woody debris abundance was 0.17 pieces per meter. Illegal cedar salvage, removal of log jams, and channelization have all contributed to low LWD abundance (Ames *et al.* 2000). Large woody debris is lacking in quality and quantity because the riparian forest is dominated by red alder with patches of conifers (May 1996). In the mid-1990s, woody debris abundance ranged from 0.078 to 0.465 pieces per meter. The non-weighted mean abundance was 0.279 pieces/m. Coniferous composition of the LWD ranged from 33 to 65%, with a non-weighted mean of 46%. A non-weighted mean of 46.8% of pieces were larger than 0.5 meter in diameter (May and Peterson 2002). Large woody debris was rated poor to fair.

Percent Pools

In the mid-1990s, percent pool surface area ranged from 16 to 93%, with a non-weighted mean of 51.3% (May and Peterson 2002). Percent pools were rated good.

Pool Frequency

Pool frequency ranged from a low of 6.4 channel widths per pool to a high of 2.3 channel widths per pool. The non-weighted mean pool frequency was 3.9 channel widths per pool (May and Peterson 2002). Pool frequency was rated fair.

Pool Quality

Recently, Jeff Cederholm noted the loss of stable and deep pools in the lower portion of the stream that were present in the 1960s. Loss of LWD and aggradation were believed to be the cause of pool loss (Ames *et al.* 2000). May and Peterson (2002) rated pool quality good to optimal on the majority of Big Beef Creek. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks) to optimal (>90% stable banks) on the majority of Big Beef Creek. Streambank stability was rated good.

Sediment Input

Sediment Supply

The natural background sediment production rate for the Big Beef Creek Watershed is 232 tons per year (Washington Department of Natural Resources 1995). Logging and road building on steep-unstable slopes in the lower portion of the watershed caused mass wasting, channel widening, and bank instability, resulting in an 8-fold increase in bedload over natural conditions. The majority of coarse sediment was deposited in lower stream reaches, filling pools, widening the channel, and reducing water depth (Madej 1978, cited in Ames *et al.* 2000). In 1969 and 1971, the entire summer chum run was relocated to the UW Research Station spawning channel because of unstable channel conditions and channelization activities in Big Beef Creek (Cederholm 1972, cited in Ames *et al.* 2000). Channelization and the WDFW fish weir have contributed to increased aggradation by constricting the channel and causing bedload deposition above the weir. The bridge causeway under Seabeck Road impedes tidal action that would aid sediment flushing (Ames *et al.* 2000). Sediment supply was rated poor.

Mass Wasting

No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density

Road density in the Big Beef Creek Watershed was 4.1 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

In the early 1990s, 32% of the riparian buffer along Big Beef Creek provided >90% canopy closure. Twenty-nine percent of the buffer provided 70 to 90% canopy closure, while the remaining 39% provided <70% canopy closure. The buffer is dominated by mixed and deciduous forests (Washington Department of Natural Resources 1995). In the mid-1990s, riparian canopy cover ranged from 25 to 90%. The non-weighted mean canopy cover was 61.3% (May and Peterson 2002). From the fish hatchery upstream to Lake Symington, logging has led to a riparian buffer dominated by red alder with patches of conifers (May 1996). The Hood Canal Salmon Sanctuary program has been purchasing key riparian habitat upstream from the UW research facility (Ames *et al.* 2000). Riparian habitat ratings in May and Peterson (2002) indicate a buffer that is wide and intact or moderately wide with some impacts from development. Mixed forests of immature and mature coniferous and deciduous trees are the dominant vegetation. Riparian condition was rated fair.

<u>Water Quality</u>

Temperature

Summer water temperatures at the outlet of Lake Symington routinely exceed salmonid habitat requirements because of the lake's shallow depth (<10') (May 1996, May and Peterson 2002). Summer water temperatures were monitored at the UW Research Station in 1992-1994, 2001 and 2002. The AIMT during this period ranged from 15.6°C to 18.3°C. The 7-DADMT at this site was 16.6°C in 2001 and 2002. Temperatures were monitored at Kidhaven Lane in 2001 and 2002. The AIMT ranged from 19.1°C to 21.1°C. The 7-DADMT ranged from 18.1°C to 19.1°C. Temperatures below Lake Symington were monitored in 1992-1994, 2001, and 2002. The AIMT ranged from 21.1°C to 26.9°C. The 7-DADMT was over 24.6°C in both 2001 and 2002. Temperatures above Lake Symington (NW Holly Road) were measured in 1992-1994, 2001, and 2002. The AIMT ranged from 14.4°C to 16.8°C. In 2001-2002 the 7-

DADMT ranged from 14.5°C to 15.8°C (Port Gamble S'Klallam Tribe 2003, Unpublished work). Temperature was rated fair to poor.

Dissolved Oxygen

No information was available.

Hydrology

Flow-Hydrologic Maturity

About 94% of the Big Beef Creek Watershed is forested. Hydrologically mature forests cover about 61% of the watershed, while immature forests cover about 21%, and intermediate maturity forests cover about 11% (Washington Department of Natural Resources 1995). Hydrologic maturity was rated good.

Flow-Percent Impervious Surfaces

As of 1995, impervious surfaces covered 6.8% of the Big Beef Creek Watershed. Impervious surface coverage was projected to increase to 14% in the future (Washington Department of Natural Resources 1995). May *et al.* (1997) reported only 3.1% total impervious area in the Big Beef Creek Watershed. Percent impervious surfaces were rated fair.

Biological Processes

No information was available to assess biological processes.

Little Beef Creek (15.0399) Watershed

Description

Little Beef Creek enters Hood Canal about 0.3 of a mile southwest of Big Beef Harbor. The stream is about two miles long (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in the Little Beef Creek Watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. May and Peterson (2002) rated artificial barriers good (<10% of habitat blocked). Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools good (30 to 40% pools). Percent pools were rated fair.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating a condition of some deep pools with cover. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable banks). Streambank stability was rated good.

Sediment Input

Sediment Supply

The natural background sediment production rate for Little Beef Creek is seven tons per year (Washington Department of Natural Resources 1995). No additional information was available.

Mass Wasting

No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density
Road density in the Little Beef Creek Watershed was 5.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition
In the early 1990s, 100% of the riparian buffer along Little Beef Creek provided 70 to 90% canopy closure. The buffer was comprised of mixed and deciduous forests (Washington Department of Natural Resources 1995). Riparian habitat ratings from May and Peterson (2002) indicate a buffer of moderate width with some encroachment from development, composed of mature coniferous trees. The mean riparian habitat condition rating was 3.7. Riparian condition was rated good to fair.

Water Quality
No water quality information was available.

Hydrology

Flow-Hydrologic Maturity
Forests cover about 92% of the Little Beef Creek Watershed. Hydrologically immature forests and hydrologically mature forests cover roughly equal portions of the watershed, about 34% and 33% respectively. Intermediate maturity forests cover about 25% of the watershed (Washington Department of Natural Resources 1995). Hydrologic maturity was rated poor.

Flow-Percent Impervious Surfaces
In 1995, impervious surfaces covered 6.2% of the Little Beef Creek Watershed. Impervious surface coverage was projected to reach 16.5% in the future (Washington Department of Natural Resources 1995). Percent impervious surfaces were rated fair.

Biological Processes
No biological processes information was available.

Seabeck Creek (15.0400) Watershed

Description
Seabeck Creek is located near the town of Seabeck. The stream drains about six square miles. The mainstem is five miles long with 16 miles of tributaries. The stream begins in wetlands on a flat glacial plain. For about two miles, the stream flows through a deep ravine cut into the low elevation rolling hills. The lower mile of stream flows through a relatively broad floodplain with moderate channel gradient (Ames *et al.* 2000). The stream discharges to a small estuary with a narrow delta (Hood Canal Coordinating Council 2002). The glacial sediments that dominate the watershed are prone to erosion.

A shallow perched aquifer supplies the majority of base flow to Seabeck Creek. The Seabeck Aquifer, a deep aquifer, supplies additional flow near the mouth of the stream (Ames *et al.* 2000). Seabeck Creek is closed to further surface water appropriations (State of Washington 1988).

A mill began operation in Seabeck in 1857 and continued until burning down in 1886. The mill concentrated on cutting oldgrowth timber along the shoreline and streams. Significant logging also took place from 1920 to 1936 during the operation of Camp Union, located in the upper Big Beef Creek Watershed. A railroad spur was constructed in the valley bottom of Seabeck Creek to transport logs. The entire watershed was completed logged by 1944 (Ames *et al.* 2000). Land use in the Seabeck Creek Watershed is a mix of rural residences, forestlands, small hobby farms, limited aquaculture, the town of Seabeck, and a marina. The watershed has undergone a dramatic increase in rural development over the last decade. Applications to convert forestland to rural development have accelerated since the late 1970s (Ames *et al.* 2000). Rural residential impacts are present along Hite-Center Road and Seabeck-Holly Road. By the mid-1990s, a large suburban development was beginning to surround the lowest eastern tributary of Seabeck Creek. Seabeck Heights consists of about 75 one acre lots located on Pope Resources' former timberlands. The development was the first in the area to incorporate stormwater mitigation facilities (May 1996).

Habitat Ratings

Access and Passage

Artificial Barriers

The culvert under Seabeck-Holly Road is undersized for flows projected under future development conditions, and a fish ladder on the downstream side of the culvert may inhibit chum passage during some flows (May 1996). May (1996) recommended replacing this culvert if development continues. A weir at RM 0.7 of the mainstem is a partial barrier. A culvert on a small unnamed tributary is a complete barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

Rural development has degraded floodplain habitat from RM 0.5 downstream to the mouth (May 1996, Ames *et al.* 2000). Riparian vegetation has been cleared, and the stream channel has been fixed (i.e. armored) at several locations. Residential development has heavily encroached upon the eastern portion of the Seabeck Creek Delta, and the bridge crossing at the mouth has diminished floodplain function (Ames *et al.* 2000). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Some wetlands are present above Hite-Center Road (May 1996). The majority of floodplain habitat present in the Seabeck Creek Watershed is found from RM 0.5 downstream (Washington Department of Natural Resources 1995). Floodplain function has been altered significantly on this reach (Ames *et al.* 2000). Loss of floodplain habitat was rated poor.

<u>Channel Conditions</u>

Fine Sediment

Timber-Fish-Wildlife ambient monitoring data from 1989 reveal high substrate embeddedness. Roads are the primary cause of increased fine sediment levels. Many of the roads are privately owned and lack maintenance and proper surfacing. Logging and runoff from rural developments are also sources of fine sediment. Runoff from construction during wet weather has periodically contributed significant levels of fine sediment to Seabeck Creek (Ames *et al.* 2000). Depressed chum populations may also contribute to increased substrate embeddedness levels since large numbers of spawning chum can effectively remove fines during redd construction (Peterson and Quinn 1994, Montgomery *et al.* 1996, both cited in Ames *et al.* 2000). Fine sediment was rated poor.

Large Woody Debris

Large woody debris is lacking in the lower reach of Seabeck Creek (May 1996). In the mid 1990s, woody debris abundance ranged from 0.056 pieces per meter on lower Seabeck Creek to 0.534 pieces per meter on upper Seabeck Creek. The non-weighted mean abundance was 0.217 pieces/m. A mean 63% of woody debris was coniferous. Pieces larger than 0.5 meter in diameter represented a mean of 42% of wood inventoried. Stream #15.0401 had 0.189 pieces per meter. Coniferous trees comprised 42% of the LWD, and 27% of pieces were larger than 0.5 meter in diameter (May and Peterson 2002). Stream cleanouts, riparian logging, and rural development have all reduced LWD abundance in the Seabeck Creek Watershed. Low LWD abundance is believed to be contributing to a lack of side channel habitat (Ames *et al.* 2000). Large woody debris was rated poor to fair.

Percent Pools

In the mid-1990s, percent pool surface area ranged from 22 to 40% on mainstem Seabeck Creek. The non-weighted mean value was 29.6%. Pools comprised 21% of surface area on stream 15.0401 (May and Peterson 2002). Percent pools were rated poor to fair.

Pool Frequency

Pool frequency on mainstem Seabeck Creek in the mid-1990s ranged from 4.9 to 3.1 channel widths per pool. The non-weighted mean pool frequency was 4.0. Stream 15.0401 had 6.1 channel widths per pool (May and Peterson 2002). Pool frequency was rated poor to fair.

Pool Quality
May and Peterson (2002) rated pool quality good throughout the mainstem of Seabeck Creek, indicating the presence of some deep pools with cover. Pool quality was rated good.

Streambank Stability
May and Peterson (2002) rated streambank stability good (75 to 90% stable banks) throughout the mainstem of Seabeck Creek. Streambank stability was rated fair.

<u>Sediment Input</u>

Sediment Supply
The natural background sediment production rate for the Seabeck Creek Watershed is 124 tons per year (Washington Department of Natural Resources 1995). Roads and residential development have increased sediment supply, causing high substrate embeddedness (Ames *et al.* 2000). Sediment supply was rated poor.

Mass Wasting
No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density
Road density in the Seabeck Creek Watershed was 3.6 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition
In the mid 1990s, riparian canopy cover on mainstem Seabeck Creek averaged 75%. Canopy cover on stream #15.0401 was 50% (May and Peterson 2002). In the early 1990s, 37% of the riparian buffer along Seabeck provided >90% canopy closure. Forty percent of the buffer provided 70 to 90% canopy closure, while 13% provided <70% canopy closure (note: Although the numbers do not equal 100%, these were the values listed in the report) (Washington Department of Natural Resources 1995). Mixed coniferous and deciduous trees less than 20 inches dbh comprise 59% of the riparian buffer. Deciduous stands comprise the remaining 41% of the riparian forest. Rural development, roads, and dikes have substantially degraded riparian habitat from the mouth to RM 0.9. The buffer along the entirety of this reach is less than 66 feet wide and composed of sparse cover (Ames *et al.* 2000). Riparian condition was rated fair to poor.

Water Quality

Temperature

Summer water temperatures were monitored at Miami Beach Road in 1992-1994 and 2001. The highest AIMT recorded was 15.6°C in 1994. All other temperature readings were less than 14°C (Labbe *et al.* 2002). Temperature was rated good.

Dissolved Oxygen

No information was available.

Hydrology

A shallow perched aquifer supplies the majority of base flow to Seabeck Creek. The Seabeck Aquifer, a deep aquifer, supplies additional flow near the mouth of the stream (Ames *et al.* 2000). Seabeck Creek is closed to further surface water appropriations (State of Washington 1988). During the summer months, flows often go subsurface on the lower two miles of stream because of coarse sediment deposition (Ames *et al.* 2000). The rise in streambed elevation has also led to increased flood frequency during minor rainfall events. The glacial sediments that dominate the Kitsap Peninsula are prone to erosion and high sediment production, but historic logging and minimal protection of riparian corridors from development and logging have accelerated the rate and magnitude of slope failures, thus overwhelming the sediment carrying capacity of the stream (Ames *et al.* 2000). Scour was noted above the lower bridge crossing on Stavis Creek Road. Streambed aggradation impedes passage of adult chum because of low stream flows and lack of holding pools; redds are vulnerable to scour during high flows and outmigrating juveniles are vulnerable to predation because of the lack of cover (Ames *et al.* 2000).

Flow-Hydrologic Maturity

Forests cover about 93% of the Seabeck Creek Watershed. Hydrologically mature forests cover roughly 51% of the land base, while intermediate maturity forests cover about 24%, and immature forests cover about 18% (Washington Department of Natural Resources 1995). Hydrologic maturity was rated poor.

Flow-Percent Impervious Surfaces

As of 1995, impervious surfaces covered 6.8% of the Seabeck Creek Watershed. Impervious surface coverage was projected to increase to 14.9% in the future (Washington Department of Natural Resources 1995). May *et al.* (1997) reported only 2.7% total impervious area in the Seabeck Creek Watershed. Percent impervious surfaces were rated fair.

Biological Processes

No information was available to assess biological processes.

Unnamed Stream (15.0403) Watershed

Description

Unnamed stream 15.0403 enters Stavis Bay about 0.3 of a mile east of the spit in Stavis Bay. The stream is about 1.6 miles in length (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at RM 0.7 is a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions optimal (natural floodplain function). Floodplain connectivity was rated good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions optimal (natural floodplain function). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment optimal (<10% fines). Fine sediment was rated good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating some deep pools with cover. Pool quality was rated good.

Streambank Stability
May and Peterson (2002) rated streambank stability optimal (>90% stable banks). Streambank stability was rated good.

Sediment Input

Sediment Supply
No information was available.

Mass Wasting
No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density
Road density in the Stream 15.0403 Watershed was 3.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition
Riparian habitat ratings in May and Peterson (2002) are indicative of a wide and intact riparian buffer composed of mature coniferous trees. The mean riparian condition rating was 4.0. Riparian condition was rated good.

Water Quality
No information was available to assess water quality conditions.

Hydrology
No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes
No information was available to assess biological processes.

Stavis Creek (15.0404) Watershed

Description
Stavis Creek enters Hood Canal at Stavis Bay, about three miles southwest of the town of Seabeck. The stream drains about seven square miles. The mainstem is five miles long with 11 miles of tributaries. Stavis Creek begins in a series of beaver ponds, and wetlands. The upper reaches flow through a steep, tightly confined ravine. The lower half-mile of stream has moderate gradient and flows across a relatively broad floodplain. The estuary and delta are relatively untouched, serving as one of the better examples of

lagoon and spit features in Hood Canal (Ames *et al.* 2000). Logging has been the dominant land use throughout Euro-American settlement. The upper portion of the watershed appears to have been logged less intensively than other areas of the Kitsap Peninsula (Ames *et al.* 2000). Rural residential land use is currently scattered along the shorelines, lower half-mile of stream, and the upper watershed. Forestry continues to be a major land use. The DNR manages the Kitsap Forest Natural Area Preserve, the largest block of timber in the watershed. Private land owners manage smaller acreages of timber. The WDFW is currently negotiating conservation easements to protect habitat within the potential summer chum distribution. Shoreline development is concentrated on the shoreline of Stavis Bay east of the mouth of Stavis Creek. The Stavis Creek Watershed has been less affected by rural development than other watersheds in the Hood Canal region (Ames *et al.* 2000).

Habitat Ratings

Access and Passage

Artificial Barriers

A weir at RM 0.1 is a partial barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). A culvert on Stavis Creek at the Seabeck-Holly Road crossing is more than 100' long, posing a velocity barrier, and the outfall has a 24" drop. Significant coho rearing habitat is available above this culvert. Although the barrier is significant, adults have been observed above the culvert (Washington Department of Natural Resources 1995). See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions optimal (natural floodplain function). Floodplain connectivity was rated good.

Loss of Floodplain Habitat

Each of the forks of Stavis Creek originate in wetlands. The community of Hintzville encroaches on the headwater wetlands of the east fork of Stavis Creek (May 1996). May and Peterson (2002) rated floodplain conditions optimal (natural floodplain function). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines) throughout the Stavis Creek Watershed. Fine sediment was rated fair to good.

Large Woody Debris

Logging along both forks of Stavis Creek has led to a lack of LWD (May 1996). May and Peterson (2002) rated LWD quantity good throughout the Stavis Creek Watershed, indicating moderate LWD abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated pools optimal (40 to 60% pools). Pool quality was rated good.

Pool Frequency

Low LWD abundance has led to reduced pool frequency (May 1996). No pool frequency data were available.

Pool Quality

May and Peterson (2002) rated pool quality good throughout the Stavis Creek Watershed, indicating some deep pools with cover. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks) on the mainstem and west fork of Stavis Creek. Bank stability was rated fair (50 to 75% stable banks) on the east fork. Streambank stability was rated fair to poor.

<u>Sediment Input</u>

Sediment Supply

The natural background sediment production rate for the Stavis Creek Watershed is 106 tons per year (Washington Department of Natural Resources 1995). Scour chain studies in the lower reaches have recorded moderate scour and fill of the streambed associated with peak winter flows. Mass wasting caused by historic logging, and removal of LWD are believed to be the causes of the unstable streambed conditions (Ames *et al.* 2000). Sediment supply was rated poor.

Mass Wasting

Seven deep-seated landslides and four shallow-rapid landslides were noted along the middle reaches of Stavis Creek. Mass wasting has increased in frequency and severity because of land use practices (Washington Department of Natural Resources 1995). In the winter of 1998-99, a large landslide on state forestland on the East Fork of Stavis Creek contributed substantial amounts of fine sediment to the stream and estuary. Biologists feared that the slide would continue to contribute fine sediment to the stream for years (Labbe 2003, Personal communication, Dunagan 2003). Mass wasting was rated poor.

Road Density

Road density in the Stavis Creek Watershed was 4.9 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

In the early 1990s, 83% of the riparian buffer along Stavis Creek provided >90% canopy closure. Twelve percent of the buffer provided 70 to 90% canopy closure, while the remaining 5% provided <70% canopy closure (Washington Department of Natural Resources 1995). Riparian habitat ratings from May and Peterson (2002) indicate a wide and intact riparian buffer composed of mature coniferous trees. The mean riparian condition rating throughout the watershed was 4.0. Riparian condition was rated good.

<u>Water Quality</u>

Temperature

Water temperatures were monitored near Stavis Bay Road during the summers of 2001 and 2002. The AIMT ranged from 14.0°C to 14.9°C, while the 7-DADMT ranged from 13.8°C to 14.9°C (Port Gamble S'Klallam Tribe 2003, Unpublished work). Water temperature was rated fair to good.

Dissolved Oxygen

No information was available.

<u>Hydrology</u>

The majority of base flow is provided by hydraulic continuity with a shallow perched aquifer. The Seabeck Aquifer, a deep aquifer, makes a smaller contribution to base flows. Flows as low as 1 cfs have been recorded on Stavis Creek (Ames *et al.* 2000). Gage 0695 (Stavis Creek near Seabeck) was operated in 1947. No maximum discharge was recorded. Minimum discharge was 6.3 cfs in late July 1947 (Garling and Molenaar 1965).

Flow-Hydrologic Maturity

Forests cover about 95% of the Stavis Creek Watershed. Hydrologically mature forests cover approximately 60% of the watershed, while immature forests cover about 30%, and intermediate maturity forests cover about 5% (Washington Department of Natural Resources 1995). Logging has altered hydrologic patterns and increased the rate of mass wasting (Ames *et al.* 2000). Hydrologic maturity was rated good.

Flow-Percent Impervious Surfaces

Impervious surfaces covered only 1.5% of the Stavis Creek Watershed (May *et al.* 1997). Percent impervious surfaces were rated good.

Biological Processes
No information was available to assess biological processes.

Boyce Creek (15.0407) Watershed

Description
Boyce Creek enters Hood Canal at Frenchman's Cove. The stream is about 3.9 miles long (Williams *et al.* 1975) and has extensive wetlands (Hood Canal Coordinating Council 2002).

Habitat Ratings

Access and Passage

Artificial Barriers
No man-made barriers are known to be present in the Boyce Creek Watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity
May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated good.

Loss of Floodplain Habitat
May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat. Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment
May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris
In the mid-1990s, woody debris abundance on Boyce Creek ranged from 0.178 to 0.250 pieces per meter. The overall mean was 0.200 pieces/m. No information was available on pieces larger than 0.5 meter in diameter or percent coniferous composition. Large woody debris recruitment potential was rated good overall (May and Peterson 2002). May and Peterson (2002) rated LWD quantity fair, indicating sparse abundance. Large woody debris abundance was rated poor to fair.

Percent Pools

Percent pool habitat ranged from 34 to 50% on Boyce Creek in the mid-1990s. The overall mean was 40% (May and Peterson 2002). Percent pools were rated fair to good.

Pool Frequency

No information was available.

Pool Quality

In the mid-1990s, the overall mean residual pool depth was 0.27 meter (May and Peterson 2002). May and Peterson (2002) rated pool quality good, indicating some deep pools with cover. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable banks). Streambank stability was rated good.

<u>Sediment Input</u>

Sediment Supply

The natural background sediment production rate for the Boyce Creek Watershed is 38 tons per year (Washington Department of Natural Resources 1995). No additional information was available.

Mass Wasting

No landslides were noted in Washington Department of Natural Resources (1995). Mass wasting was rated good.

Road Density

Road density in the Boyce Creek Watershed was 5.4 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Mid-1990s habitat surveys measured an overall riparian canopy cover of 85% on Boyce Creek (May and Peterson 2002). In the early 1990s, 43% of the riparian buffer along Boyce Creek provided >90% canopy closure. Forty-six percent of the buffer provided 70 to 90% canopy closure, while the remaining 11% provided <70% canopy closure (Washington Department of Natural Resources 1995). Riparian habitat ratings from May and Peterson (2002) indicate a wide and intact riparian buffer composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

No water quality information was available.

Hydrology

Flow-Hydrologic Maturity

Forests cover about 84.5% of the Boyce Creek Watershed. Mature forests cover about 64.5% of the watershed, while immature forests cover about 17.5%, and intermediate maturity forests cover 2.5% (Washington Department of Natural Resources 1995). Hydrologic maturity was rated good.

Flow-Percent Impervious Surfaces

No information was available.

Biological Processes

No information was available to assess biological processes.

Harding Creek (15.0408) Watershed

Description

Harding Creek enters Hood Canal about 0.5 of a mile southwest of the community of Nellita. The stream is about one mile long with several tributaries (Williams *et al.* 1975) and numerous wetlands. Commercial forestlands are the dominant land cover. Rural residential development has been minimal (Hood Canal Coordinating Council 2002).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at RM 0.7 has an 18" drop at the outfall. The culvert is a barrier to upstream juvenile migration and may block adults (Washington Department of Natural Resources 1995). This barrier is listed as a cascade on Map 26. Two additional barriers are present at forest road crossings downstream from the barrier identified above. The culvert on the North Fork is not depicted on Map 26, while the cascade identified on the South Fork is actually a culvert. Both of these culverts would be relatively easy to replace, but it is not known how much salmonid habitat is available upstream (Labbe 2003, Personal communication). Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

<u>Channel Conditions</u>

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

In the mid-1990s, large woody debris abundance on mainstem Harding Creek ranged from 0.122 to 0.283 pieces per meter. The non-weighted mean for the mainstem was 0.194 pieces/m. Stream 15.0409 had 0.178 pieces/m, while stream 15.0410 had 0.212 pieces/m. The overall mean for the entire watershed was 0.200 pieces/m. No information was available regarding pieces greater than 0.5 meter in diameter or percent coniferous composition. Woody debris recruitment potential was rated good overall for the watershed (May and Peterson 2002). Large woody debris was rated poor to fair.

Percent Pools

Percent pool surface area ranged from 2 to 57% on the mainstem of Harding Creek in the mid-1990s. The non-weighted mean was 21%. Stream 15.0409 had 7% pool surface area. Stream 15.0410 had 17% pool surface area. The overall percent pool surface area for the watershed was 29% (May and Peterson 2002). Percent pools were rated poor to fair.

Pool Frequency

No information was available.

Pool Quality

In the mid-1990s, mean residual pool depth on mainstem Harding Creek ranged from 0.15 to 0.61 meters. Streams 15.0409 and 15.0410 had a mean residual pool depth of 0.23 meters. Overall mean residual pool depth for the entire watershed was 0.36 meters (May and Peterson 2002). May and Peterson (2002) rated pool quality good, indicating the presence of some deep pools with cover. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable banks). Streambank stability was rated good.

<u>Sediment Input</u>

Sediment Supply

The natural background sediment production rate for Harding Creek is 34 tons per year (Washington Department of Natural Resources 1995). Numerous landslides and a high road density suggest that the sediment production rate would exceed the natural rate (TAG 2003). Sediment supply was rated suspected poor.

Mass Wasting

Land use practices have increased the frequency and magnitude of mass wasting events. Numerous shallow-rapid landslides and one deep-seated landslide were reported in Washington Department of Natural Resources (1995). Mass wasting was rated poor.

Road Density

Road density in the Harding Creek Watershed was 3.7 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

In the early 1990s, 82% of the riparian buffer along Harding Creek provided >90% canopy closure. The remaining 18% of the buffer provided <70% canopy closure (Washington Department of Natural Resources 1995). Riparian habitat ratings from May and Peterson (2002) indicate a wide and intact riparian buffer composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

<u>Water Quality</u>

Temperature

Summer water temperatures near the mouth of Harding Creek were monitored in 2001. The AIMT was 12.5°C. The 7-DADMT was 12.4°C, while the 21-day average daily temperature was 11.0°C (Labbe *et al.* 2002). Temperature was rated good.

Dissolved Oxygen

No information was available.

<u>Hydrology</u>

Flow-Hydrologic Maturity

Forests cover about 98% of the Harding Creek Watershed. Hydrologically mature forests cover about 80% of the watershed, while immature forests cover about 11%, and intermediate maturity forests cover about 6% (Washington Department of Natural Resources 1995). Hydrologic maturity was rated good.

Flow-Percent Impervious Surfaces

No information was available.

<u>Biological Processes</u>

No information was available to assess biological processes.

Anderson Creek (15.0412) Watershed

Description

Anderson Creek (locally known as Big Anderson Creek) enters Hood Canal about 0.5 miles north of the town of Holly. The stream drains about five square miles. The mainstem is four miles long with an additional 13 miles of tributaries. The stream originates in wetlands, and then flows through a confined ravine prior to entering a broad floodplain about 0.5 miles above the mouth. Anderson Creek discharges into a small estuary with a large intertidal delta. Industrial forestry is the principal land use in the watershed (Ames *et al.* 2000). The forests are managed by Pope Resources, Manke Lumber (May 1996) and the DNR (Ames *et al.* 2000). Logging has impacted the headwaters and many tributaries. However, several headwater wetlands are still functional (May 1996).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at Nellita-Hintzville Road is a complete barrier on the upper mainstem of Anderson Creek (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

Roads limit floodplain function on the lower half-mile of stream. A county road built across the estuary and stream mouth constrains floodplain access and may limit tidal flushing of sediments (Ames *et al.* 2000). An old Manke & Sons forest road (no longer used for forest management) is now used to access a private residence about 0.33 miles upstream from the Seabeck-Holly Road crossing. The homeowner has modified the stream channel and armored the toe of the road fill on several occasions to protect the road. Although this road occupies only a small portion of the floodplain, it restricts access to several small wetlands and degrades riparian function (Labbe 2003, Personal communication). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

The lower reaches of the stream are characterized by riparian wetlands and beaver activity (May 1996). May and Peterson rated floodplain conditions good (<25% lost floodplain habitat) to optimal (natural floodplain function) in the majority of the watershed. Loss of floodplain habitat was rated fair to good.

Channel Conditions

Fine Sediment

Logging roads, bank erosion, and landslides have contributed additional sediment to the stream, causing elevated fine sediment levels in the lower mile of stream. Although fine sediment levels are high, some of this is attributed to numerous beaver ponds in the lower half-mile of stream (Ames *et al.* 2000). May and Peterson (2002) rated fine sediment good (10 to 15% fines) throughout the Anderson Creek Watershed. Fine sediment was rated fair to good.

Large Woody Debris

Large woody debris has been lost because of riparian logging and channel cleaning activities. Downstream from RM 1.8, LWD abundance was 0.3 pieces per meter. Most woody debris (87%) was less than 20 inches in diameter. Key pieces for this channel size are >22 inches in diameter (Ames *et al.* 2000). In the mid-1990s, large woody debris abundance on the mainstem of Anderson Creek ranged from 0.289 to 0.372 pieces per meter (non-weighted mean = 0.324/m). The percentage of pieces >0.5 meter in diameter ranged from 29 to 46% (non-weighted mean = 36%). Woody debris recruitment potential was rated good on the lower reach, fair in the middle reach, and poor in the upper reach. Coniferous woody debris comprised 22% of the pieces inventoried on the lower reach, 40% on the middle reach, and 55% on the upper reach (May and Peterson 2002). Woody debris abundance on stream 15.0413 was 0.294 pieces per meter, 28% of which was greater than 0.5 meter in diameter. Coniferous trees comprised 39% of the pieces inventoried. Woody debris abundance on stream 15.0414 ranged from 0.169 to 0.222 pieces per meter. The non-weighted mean abundance was 0.197 pieces/m. A mean of 28.5% of pieces inventoried were larger than 0.5 meter in diameter. Coniferous trees comprised a mean of 34% of the woody debris inventoried on stream 15.0414. Woody debris abundance was 0.178 pieces per meter on stream 15.0415, with 33% of the pieces larger than 0.5 meter in diameter (May and Peterson 2002). Large woody debris was rated fair to poor.

Percent Pools

Pools comprised 62% of the channel on the lower reach of Anderson Creek, 40% on the middle reach, and 17% on the upper reach in the mid-1990s. The non-weighted mean was 40%. Pools comprised 19% of stream 15.0413. Pool surface area on stream 15.0414 ranged from 18 to 37%, with a non-weighted mean of 27%. Pools comprised 16% of surface area on stream 15.0415 (May and Peterson 2002). Percent pools were rated good to poor.

Pool Frequency

In the mid-1990s, pool frequency ranged from a low of 7.7 channel widths per pool on the upper reach to a high of 1.5 channel widths per pool on the lower reach of mainstem Anderson Creek. The non-weighted pool frequency for the mainstem was 3.8 channel widths per pool. Pool frequency on stream 15.0413 was 6.4 channel widths per pool. Pool frequency ranged from a low of 7.5 channel widths per pool to a high of 2.5 channel widths per pool on stream 15.0414. Mean pool frequency on stream 15.0414 was 4.6

channel widths per pool. Stream 15.0415 had a pool frequency of 7.5 channel widths per pool (May and Peterson 2002). Downstream from RM 1.8 pool frequency was 1.7 channel widths per pool. Beaver have enhanced pool habitat on this reach (Ames *et al.* 2000). Pool frequency was rated good to poor.

Pool Quality

Mean residual pool depth on mainstem Anderson Creek ranged from 0.29 to 0.44 meter in the mid-1990s. The non-weighted grand mean residual pool depth was 0.37 meter. Mean residual pool depth on stream 15.0413 was 0.21 meter. Mean residual pool depth on stream 15.0414 ranged from 0.21 to 0.33 meter, with a non-weighted grand mean of 0.27 meter. Mean residual pool depth on stream 15.0415 was 0.31 meter (May and Peterson 2002). May and Peterson (2002) rated pool quality optimal to good on the lower 1.5 miles of the mainstem. Pool quality on stream 15.0413 was rated good. Stream 15.0414 and the upper mainstem received fair pool quality ratings. These ratings indicate that deep pools with cover are frequent or somewhat common on the lower mainstem and stream 15.0413, while there are a few deep pools with little cover on the upper mainstem and stream 15.0414. Pool quality was rated good to fair.

Streambank Stability

A portion of the mainstem of Anderson Creek has been straightened, armored, and cleared of LWD. Gabions were installed to stabilize the altered channel, but high flows destroyed the majority of these structures (May 1996). The channel is unstable and braided with high sediment loads and elevated peak flows (Ames *et al.* 2000). May and Peterson (2002) rated streambank stability optimal (>90% stable banks) to good (75 to 90% stable banks) in the majority of the watershed. Streambank stability was rated good to fair.

<u>Sediment Input</u>

Sediment Supply

The natural background sediment production rate for the Anderson Creek Watershed is 179 tons per year (Washington Department of Natural Resources 1995). Numerous landslides, degraded riparian buffers, and a high road density suggest that the sediment production rate would exceed the natural rate (TAG 2003). Sediment supply was rated suspected poor.

Mass Wasting

Degraded riparian conditions and mass wasting are expected to cause channel degradation for at least several decades (Ames *et al.* 2000). Land use practices have increased the frequency and magnitude of mass wasting events. Two large deep-seated landslides and seven shallow-rapid landslides were identified in Washington Department of Natural Resources (1995). Mass wasting was rated poor.

Road Density

Road density in the Anderson Creek Watershed was 4.1 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries

Commission 2003). Extensive road building is thought to be the cause of peak flows that have increased in frequency, magnitude, and duration. This has caused bank erosion, aggradation (braiding), and channel instability on the lower stream reaches (Ames *et al.* 2000). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Data from the mid-1990s indicated riparian canopy cover values of 83% on the lower reach of Anderson Creek, 89% on the middle reach, and 92% on the upper reach (May and Peterson 2002). In the early 1990s, 40% of the riparian buffer provided >90% canopy closure. Forty-three percent of the buffer provided 70 to 90% canopy closure, and 19% of the buffer provided <70% canopy closure (Washington Department of Natural Resources 1995). Roads occupy 36% of the riparian zone, with agriculture practiced in an additional nine percent. Deciduous trees dominate 77% of the riparian corridor. About 44% of the trees are small in diameter. More than half of the riparian corridor (59%) is vegetated with a forest buffer <66 feet wide. The narrow buffers and low percentage of coniferous trees will limit future LWD recruitment (Ames *et al.* 2000). Riparian condition was rated poor.

<u>Water Quality</u>

Temperature

Summer water temperatures were monitored near Seabeck-Holly Road in 1992-1994 and 2001. The AIMT was 15.0°C in 1992, 12.8°C in 1993, 13.9°C in 1994, and 14.1°C in 2001. The 7-DADMT in 2001 was 13.8°C, while the 21-day average daily temperature was 11.8°C (Labbe *et al.* 2002). Temperature was rated good.

Dissolved Oxygen

No information was available.

<u>Hydrology</u>

Gage 0690 (Anderson Creek near Holly) was operated in 1947. No maximum discharge was recorded. Minimum discharge was 4.8 cfs from late July to early August 1947 (Garling and Molenaar 1965). Logging and road building have caused increases in peak flow frequency and magnitude (Ames *et al.* 2000).

Flow-Hydrologic Maturity

Forests cover 97% of the Anderson Creek Watershed. About 75% of the watershed is hydrologically mature. Immature forests comprise about 20%, and intermediate maturity forests cover about 3% (Washington Department of Natural Resources 1995). Hydrologic maturity was rated good.

Flow-Percent Impervious Surfaces

As of 1995, impervious surfaces covered 3.4% of the Anderson Creek Watershed. Impervious surface coverage was projected to reach 12.4% in the future (Washington

Department of Natural Resources 1995). May *et al.* (1997) reported only 1.2% total impervious area in the Anderson Creek Watershed. Percent impervious surfaces were rated fair.

Biological Processes

No information was available to assess biological processes.

Thomas Creek (15.0417) Watershed

Description

Thomas Creek enters Hood Canal about 0.3 of a mile northeast of the community of Holly. The stream is about 0.9 of a mile long with several small tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

A perched culvert on Thomas Creek at the Seabeck-Holly Road crossing is impassible to chum and upstream migrating juvenile salmonids (Washington Department of Natural Resources 1995). See Map 26. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity fair, indicating sparse abundance. Large woody debris was rated poor.

Percent Pools

May and Peterson (2002) rated percent pool surface area fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality fair, indicating a few deep pools are present with little cover. Pool quality was rated fair.

Streambank Stability

May and Peterson (2002) rated streambank stability fair (75 to 90% stable banks). Streambank stability was rated fair.

<u>Sediment Input</u>

Sediment Supply

The natural background sediment production rate for the Thomas Creek Watershed is 18 tons per year (Washington Department of Natural Resources 1995). Mass wasting and a high road density suggest that sediment production would exceed the natural rate (TAG 2003). Sediment supply was rated suspected poor.

Mass Wasting

One deep-seated landslide and two shallow-rapid landslides were reported by Washington Department of Natural Resources (1995). Mass wasting was rated poor.

Road Density

Road density in the Thomas Creek Watershed was 6.5 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

In the early 1990s, riparian buffers along Thomas Creek generally did not provide adequate canopy closure. Sixty-nine percent of the buffers provided <70% canopy closure, while 31% provided >90% canopy closure (Washington Department of Natural Resources 1995). Riparian habitat ratings from May and Peterson (2002) indicate a buffer of moderate width with some impacts from development, comprised of a mix of immature and mature deciduous trees. The mean riparian condition rating was 2.7. Riparian condition was rated fair to poor.

<u>Water Quality</u>

No water quality information was available.

Hydrology

Considering its small size, Thomas Creek maintains unusually high and constant flows throughout the year. The stream is only about ¾ mile long with a drainage area of about 0.4 square miles, yet flows generally remain in excess of two cfs. Mean annual precipitation for this watershed is 46 inches, but 72 inches would be needed to maintain the observed stream flows. Ground water is believed to provide the majority of flow to Thomas Creek (Garling and Molenaar 1965).

Flow-Hydrologic Maturity

Forests cover roughly 92% of the Thomas Creek Watershed. Hydrologically mature forests comprise about 55% of land cover, while immature forests cover about 26% of the watershed, and intermediate maturity forests cover about 11% (Washington Department of Natural Resources 1995). Hydrologic maturity was rated poor.

Flow-Percent Impervious Surfaces

No information was available.

Biological Processes

No information was available to assess biological processes.

TAHUYA-DEWATTO SUBBASIN HABITAT LIMITING FACTORS

Subbasin Description

The Tahuya-Dewatto Subbasin is the largest subbasin in west WRIA 15 and drains 99 square miles of land from the community of Holly south and east to the eastern boundary of the Tahuya River Watershed. See Map 5. The Tahuya and Dewatto Rivers are the largest streams within this subbasin. Intensive rural residential development has taken place along the shorelines of Hood Canal and area lakes (Puget Sound Cooperative River Basin Team 1991, Ames *et al.* 2000). Descriptions of individual watersheds are located in the habitat descriptions that follow.

Unnamed Stream (15.0418) Watershed

Description

Stream 15.0418 enters Hood Canal about 2.1 miles southwest of the community of Holly. The stream is about 0.7 of a mile long (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No barriers are known to be present. Man-made barriers are unlikely to be present since no roads have been built in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

No information was available to assess floodplain conditions.

Channel Conditions

No information was available to assess channel conditions.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

No roads were identified in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated good.

Riparian Zones

Riparian Condition

No information was available.

Water Quality
No water quality information was available.

Hydrology
No hydrology information was available.

Biological Processes
No biological processes information was available.

Dewatto River (15.0420) Watershed

Description
The Dewatto River enters Hood Canal about 5.5 miles north of The Great Bend of Hood Canal. The Dewatto flows down a glacial outwash channel in a southwesterly direction generally parallel to the Canal. The stream drains about 23 square miles of land (Ames *et al.* 2000). The mainstem is 8.7 miles in length (Williams *et al.* 1975), with about 30 miles of tributaries (Ames *et al.* 2000). The Dewatto River originates in glacial till, outwash sands and gravels. Glacial till is moderately erodible, but the outwash is highly erodible. Sediment entering the stream is deposited on point bars and a delta at the mouth of the stream (Puget Sound Cooperative River Basin Team 1991). The watershed is sparsely developed. Land cover is dominated by second growth timber and dense underbrush. Residences are scattered throughout the drainage, with several large parcels used for Christmas tree production. The watershed is characterized by gently rolling hills (Williams *et al.* 1975, Ames *et al.* 2000). The Dewatto valley narrows near the mouth, but the reduction is not extreme. Gradient is generally moderate throughout the length of the stream, but several wetlands are present in areas with low gradients. These reaches provide quality rearing habitat for juvenile salmonids (Williams *et al.* 1975). Many of the small tributaries go dry in the summer and winter during dry spells (Ames *et al.* 2000). The river is closed to further consumptive appropriations from June 15 to October 15 (State of Washington 1988). Logging was historically the dominant land use within the watershed. Today, a large portion of the watershed is still managed for timber production. When compared to other watersheds in west WRIA 15, the Dewatto River is in relatively good condition. Habitat is recovering from logging between 1915 and 1930, when all of the oldgrowth trees were logged. The Dewatto estuary has been relatively undisturbed (Ames *et al.* 2000).

Habitat Ratings

Access and Passage

Artificial Barriers
A culvert on stream 15.0420C is a partial barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. A culvert near RM 1.0 on Windship Creek (15.0436) is at least a partial velocity barrier to adult

and juvenile salmonids during high flows (Ereth 2003, Personal communication). See Figure 1. Artificial barriers were rated good overall.

<u>Floodplains</u>

Floodplain Connectivity

Land along the lower river channel is relatively undeveloped (Ames *et al.* 2000). May and Peterson (2002) rated floodplain conditions on the lower mile of the Dewatto River and all tributaries examined in their report good (<25% lost connectivity). From RM 1.0 to the headwaters, floodplain conditions were rated optimal (natural floodplain function). Floodplain connectivity was rated good to fair.

Loss of Floodplain Habitat

Wetlands, side channels, and beaver ponds along the mainstem Dewatto River provide substantial off-channel habitat (Bernthal and Rot 2001). May and Peterson (2002) rated floodplain conditions on the lower mile of the Dewatto River and all tributaries examined in their report good (<25% lost floodplain habitat). From RM 1.0 to the headwaters, floodplain conditions were rated optimal (natural floodplain function). Loss of floodplain habitat was rated good for the entire watershed.

<u>Channel Conditions</u>

Fine Sediment

In 1994, a total of 24 substrate samples (12 samples from each of two reaches) were collected on the mainstem Dewatto River from RM 3.0 to 3.2 and RM 4.4 to 5.6. Fine sediment levels (less than 0.85 mm) ranged from 9 to 28% (mean 20.5%) on the lower reach, and 9 to 24% (mean 15.2%) on the upper reach. Sand and gravel were the dominant substrates (each 38% of total). Cobble comprised 21% of the substrate (Bernthal and Rot 2001). Ames *et al.* (2000) contends that substrate embeddedness levels are high as a result of logging and road building. However, the embeddedness values on the upper 1.2 mile long reach are likely more representative of the system than those measured on the lower 0.2 mile long reach. Substrate in the Dewatto is generally loose gravel that can easily be scooped up with your bare hands (Boad 2003, Personal communication). May and Peterson (2002) rated fine sediment optimal (<10% fines) for the entire Dewatto Watershed. Fine sediment was rated good to poor.

Large Woody Debris

The WDF SID removed numerous logjams and woody debris from the Dewatto River in 1970 (Amato 1996). In 1994, LWD total abundance averaged 1.1 pieces per channel width from RM 3.0 to RM 3.5. Key pieces were uncommon, with an abundance of 0.06 pieces per channel width. From RM 4.4 to RM 7.7, total LWD abundance was 0.55 pieces per channel width. Key piece abundance was 0.09 pieces per channel width. *Note that these values are weighted by stream reach length* (Bernthal and Rot 2001). In the late 1990s, the Hood Canal Salmon Enhancement Group conducted extensive stream surveys within the Dewatto Watershed (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Total LWD abundance on the mainstem Dewatto River was 3.94

pieces per channel width, with 0.82 key pieces per channel width. Coniferous wood comprised 45% of the pieces inventoried on the mainstem. Large woody debris abundance data for tributaries of the Dewatto River are summarized in Table 3. Large woody debris was rated good on the mainstem and fair on the tributaries.

Table 3. Dewatto River Watershed Large Woody Debris Abundance.

Stream Name	Stream No.	Survey Length (meters)	LWD Total Pieces/ Channel Width (% conifer)	LWD Key Pieces (>0.50 meters dia.) per Channel Width
Dewatto River	15.0420	14,500	3.94 (45%)	0.82
White Creek	15.0421	2,500	4.71 (44%)	0.43
White Creek Tributary	15.0422	3,000	1.83 (39%)	0.30
Shoe Creek	15.0424	4,000	2.34 (51%)	0.43
Larson Creek	15.0425	1,500	0.45 (57%)	0.10
Alder Creek	15.0426	1,500	2.92 (ND)	0.42
Ralph Creek	15.0428	1,500	1.48 (ND)	0.29
Oak Creek	15.0429	3,500	1.65 (ND)	0.45
Unnamed Stream	15.0431	500	2.29 (ND)	0.10
Ludvick Lake Creek	15.0435	2,000	1.18 (40%)	0.31
Blacksmith Lake Creek	15.0436	2,500	2.38 (ND)	0.26

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. ND = No data.

Percent Pools

Surveys conducted by HCSEG in the late 1990s measured an average pool surface area on the Dewatto River mainstem of 72.6%. Percent pool surface areas of tributary streams are summarized in Table 4. Percent pools were rated good on the mainstem Dewatto River and Shoe Creek, and poor on the other tributaries identified in the table below.

Table 4. Dewatto River Watershed Percent Pool Surface Area.

Stream Name	Stream No.	Survey Length (meters)	Mean Percent Pool Surface Area
Dewatto River	15.0420	14,500	72.6
White Creek	15.0421	2,500	25.3
White Creek Tributary	15.0422	3,000	16.4
Shoe Creek	15.0424	4,000	48.1
Larson Creek	15.0425	1,500	27.6
Alder Creek	15.0426	1,500	ND
Ralph Creek	15.0428	1,500	ND
Oak Creek	15.0429	3,500	ND
Unnamed Stream	15.0431	500	ND
Ludvick Lake Creek	15.0435	2,000	0.6
Blacksmith Lake Creek	15.0436	2,500	ND

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. ND = No data.

Pool Frequency

In 1994, between RM 3.0 and 3.5, weighted mean pool frequency was 4.7 channel widths per pool. From RM 4.4 to RM 7.7, weighted mean pool frequency was 2.9 channel widths per pool. The majority of pools were created by LWD, tree roots, and beaver dams (Bernthal and Rot 2001). Pool frequency was rated poor on the lower reach and fair on the upper reach.

Pool Quality

In 1994, from RM 3.0 to 3.5, 52% of pools had a residual pool depth between 0.5 and 1.0 meter deep, 33.5% of pools were less than 0.5 meter deep, and 14.5% of pools were greater than 1.0 meter deep. From RM 4.4 to RM 7.7, 49% of pools were 0.5 to 1.0 meter deep, 34% were less than 0.5 meter deep, and 17% were greater than 1.0 meter deep (Bernthal and Rot 2001). May and Peterson (2002) rated pool quality optimal throughout the entire Dewatto River Watershed. This rating indicates a condition of frequent deep pools with cover. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable banks) throughout the entire watershed. Streambank stability was rated good for the entire watershed.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Dewatto River Watershed was 4.3 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

According to Ames *et al.* (2000) the riparian corridor was 87% forested. Home sites and agriculture collectively comprised six percent of riparian land use. The majority of trees in the Dewatto River riparian buffer were less than 20 inches dbh (32% < 12 inches, 68% 12 to 20 inches) (Ames *et al.* 2000). However, mature trees are scattered throughout the length of the Dewatto River riparian buffer (Boad 2003, Personal communication). The vast majority of the buffer (96%) was comprised of a mix of coniferous and deciduous trees. The majority of the buffer was relatively wide (69% >132 wide). Fifteen percent of the buffer was less than 66 feet wide. The remainder of the buffer (16%) was 66 to 132 feet in width or sparsely vegetated. Logging and road building have led to reduced woody debris abundance and species diversity within the riparian buffer (Ames *et al.* 2000). Riparian canopy closure ranged from 70 to 78% between RM 3.0 and 3.5. The weighted mean value was 75%. From RM 4.4 to RM 7.7, canopy closure ranged from 40 to 94% with a weighted mean value of 80% (Bernthal and Rot 2001). Riparian habitat ratings from May and Peterson (2002) on the Dewatto River and tributaries indicate a moderately wide riparian buffer composed of a mix of mature and immature conifers. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

<u>Water Quality</u>

Temperature

Water temperatures at RM 1.5 of the Dewatto River exceeded the state AA standard of 16ºC only one day during August 1994. However, the maximum preferred juvenile salmonid rearing temperature of 14ºC was exceeded 27 times during the 31 days measurements were taken. Upstream at RM 2.5 temperatures exceeded 16ºC four times, and 14ºC 20 times. During August of 1995, water temperatures at RM 0.6 exceeded 16ºC four times and 14ºC 29 times. Conditions were similar upstream at RM 1.9 where 16ºC was exceeded four times and 14ºC was exceeded 27 times (Bernthal and Rot 2001). Unpublished water temperature data gathered by the Skokomish Tribe revealed the following temperature trends. In 1996 at RM 0.3, temperatures exceeded 14°C for 47 consecutive days from mid-July through early September. Temperatures exceeded

16.3°C on 20 days. The maximum temperature recorded was 18.2°C. During the same time period temperatures upstream at RM 7.4 exceeded 14°C for 48 consecutive days. Minimum daily temperatures fell below 14°C only seven times during this stretch. Temperatures exceeded 16.3°C on 32 days, and 20°C was exceeded on three days. The same sites were monitored in the summer of 1997. At RM 0.3, temperatures exceeded 14°C for 60 consecutive days and exceeded 16.3°C 22 times. Maximum temperatures exceeded 17°C on six days. At RM 7.4, 14°C was exceeded for 61 consecutive days and 16.3°C was exceeded on 48 days. During this period, temperatures exceeded 16.3°C for 41 consecutive days. Temperatures fell below 14°C on only five days. Temperatures exceeded 18°C twenty times. The maximum temperature recorded was 19.5°C (Ereth 2003, Personal communication). Temperature was rated fair to poor.

Dissolved Oxygen

No information was available.

<u>Hydrology</u>

Gage 0685 (Dewatto River near Dewatto) was operated from 1947-1954 and from 1958 to an unknown date. Maximum discharge was 2,110 cfs 11/3/1955 *(although this date does not agree with the described period of record, it was reported as it appears here)*. Minimum discharge was 9.6 cfs 9/22/1950. Flows in the Dewatto River are believed to be enhanced by ground water that migrates laterally from the Tahuya River (Garling and Molenaar 1965). As of 1963, only two surface water rights were established in the Dewatto River Watershed. Water was diverted from tributary streams (0.31 cfs for irrigation and 0.02 cfs for domestic supply). No ground water claims were on file at that time (Garling and Molenaar 1965). No information was available to assess hydrologic maturity or percent impervious surfaces.

<u>Biological Processes</u>

No biological processes information was available.

Little Dewatto Creek (15.0438) Watershed

Description

Little Dewatto Creek enters Hood Canal about 0.7 of a mile southwest of the community of Dewatto. The stream is 1.7 miles long with several small tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

No information was available to assess floodplain conditions.

Channel Conditions

No information was available to assess channel conditions.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Little Dewatto Creek Watershed was 3.5 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

No information was available.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

Rendsland Creek (15.0439) Watershed

Description

Rendsland Creek enters Hood Canal between Musqueti and Bald Points near the Great Bend of Hood Canal. The mainstem is 5.3 miles long with 4.4 miles of tributaries (Williams *et al.* 1975). The stream originates at Tee Lake. The outlet of the lake is seasonal and the stream flows through a large wetland complex known locally as "The Peat Bog" (Ereth 2003, Personal communication). Topography is characterized by low-lying hills. The watershed is sparsely developed with the exception of rural residences near the mouth. Land cover is dominated by second growth timber and small Christmas tree farms. Riparian cover is dense. The stream channel is quite stable and provides "excellent" spawning conditions. Gradient is generally moderate, but is steeper in the upper reaches. Gravel is the dominant substrate. The lower reach is intermittent, but other reaches are perennial and provide salmonid rearing habitat (Williams *et al.* 1975). A well-developed delta is present at the mouth (Puget Sound Cooperative River Basin Team 1991).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert in the headwaters is a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. A culvert at the Dewatto Bay crossing of Rendsland Creek is a partial barrier. Tee Lake residents manipulate lake levels at the culvert outfall, potentially disrupting movement of adult and juvenile salmonids into the lake. Several culverts are present on tributaries flowing through private timberlands. These streams and culverts should be inventoried for fish presence and fish passage (Ereth 2003, Personal communication). Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated good to fair.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

The WDF SID removed logjams from Rendsland Creek in 1969 (Amato 1996). May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pool surface area good (30 to 40% pools). Percent pools were rated fair.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable banks). Streambank stability was rated good.

<u>Sediment Input</u>

Sediment Supply

No recent information was available. Historically sediment loads were increased significantly through erosion caused by extensive logging of the watershed (Washington Department of Fisheries 1932, cited in Amato 1996).

Mass Wasting

Hillside erosion associated with logging operations was contributing large amounts of gravel to the channel in the 1930s (Washington Department of Fisheries 1932, cited in Amato 1996). No recent information was available.

Road Density

Road density in the Rendsland Creek Watershed was 4.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) correspond to a wide and intact riparian buffer composed of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.7. Riparian condition was rated fair to good.

Water Quality

No water temperature information was available.

Hydrology

Rendsland Creek goes dry at the mouth during the summer months. The stream appears to receive little base flow from ground water. Consequently, flows are dependent on surface runoff (Garling and Molenaar 1965). Although the lower and upper reaches of Rendsland Creek are intermittent, the middle reach of the stream downstream from the Peat Bog maintains perennial flows (Ereth 2003, Personal communication). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No biological processes information was available.

Browns Creek (15.0444) Watershed

Description

Browns Creek enters Hood Canal about one mile east of Bald Point (Williams *et al.* 1975). The stream is about 1.5 miles long (Hood Canal Coordinating Council 2002).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert under Northshore Road (RM 0.07) is a partial barrier. A culvert upstream at RM 0.15 is a complete barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated good to fair.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pool area fair (20 to 30% pools). Percent pools were rated fair to poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Browns Creek Watershed was 5.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) are indicative of a moderately wide riparian buffer composed of a mix of mature and immature conifers. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

<u>Water Quality</u>

No water quality information was available.

<u>Hydrology</u>

No hydrology information was available.

<u>Biological Processes</u>

No biological processes information was available.

Caldervin Creek (15.0445) Watershed

Description

Caldervin Creek enters Hood Canal just north of the mouth of the Tahuya River. The stream is 1.5 miles in length (Hood Canal Coordinating Council 2002). The stream flows through a small and narrow valley with a steep gradient in the upper reaches. The lower half-mile has a more moderate gradient with "excellent" spawning gravel. The channel is stable and composed primarily of riffles. Stream banks are more developed than other streams in the WRIA, so bank cover is less dense (Williams *et al.* 1975). Land along the lower half-mile of stream is developed with single family residences (Ereth 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated good to fair.

Loss of Floodplain Habitat

The right bank of the mouth of Caldervin Creek was historically a large mudflat, indicating that the channel likely migrated across an alluvial fan (Point No Point Treaty Council 2003, Unpublished work). The mudflat was filled and homes are now present on both sides of the stream (Washington Department of Ecology 2000b). See oblique photo #145406. May and Peterson rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pool surface area good (30 to 40% pools). Percent pools were rated fair.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable banks). Streambank stability was rated good.

<u>Sediment Input</u>

Sediment Supply

Caldervin Creek is actively downcutting through the glacial advance outwash sediments deposited in this area. The stream erodes and transports relatively large amounts of sediment downstream where it is deposited at the mouth (Puget Sound Cooperative River Basin Team 1991). No information on sediment production rates was available.

Mass Wasting

Poor placement of a logging road on private timberlands caused a large mass wasting event in the early 1990s. A large amount of sediment and debris were deposited in the channel. Within a few years the sediment pulse and large woody debris had been distributed throughout the system (Ereth 2003, Personal communication). Mass wasting was rated good since it appears that the watershed has recovered from the event described above.

Road Density

Road density in the Caldervin Creek Watershed was 4.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) correspond to a wide and intact riparian buffer composed of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.7. Riparian condition was rated fair to good.

Water Quality

Temperature

The Skokomish Tribe monitored water temperatures in a forested reach upstream from RM 0.5 in 1997. Temperatures were extremely stable, ranging from 10 to 12°C. Maximum temperatures barely exceeded 12°C (Ereth 2003, Personal communication). Temperature was rated good.

Dissolved Oxygen

No information was available.

Hydrology

Flow in Caldervin Creek is largely dependent upon groundwater. As groundwater withdrawals increase, flows decrease, particularly during dry weather. During low flow conditions the stream is not able to transport its sediment load and the channel subsequently aggrades. Sand and gravel have accumulated in the lower reach, causing flooding near the mouth. Under natural conditions, the stream would cut a new channel through the delta, but residential development prevents channel migration on the lower reach (Puget Sound Cooperative River Basin Team 1991). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No biological processes information was available.

Tahuya River (15.0446) Watershed

Description

The Tahuya River is the largest stream on the Kitsap Peninsula (Williams *et al.* 1975), draining 45 square miles of land. Gently rolling hills are the dominant terrain. The mainstem is 21 miles long with an additional 65 miles of tributaries (Ames *et al.* 2000). The numerous tributaries are an important factor in the Tahuya's ability to produce large numbers of coho salmon. Portions of the mainstem and tributaries have low gradients and wetlands with dense vegetation. These reaches are important rearing areas for juvenile coho (Williams *et al.* 1975). Development is intense on the shoreline of Hood Canal and along many of the lakes, reservoirs, and wetlands within the watershed (Ames *et al.* 2000). The Tahuya flows through an extensive glacial outwash channel. The river originates at the base of Green Mountain from Tin Mine Creek, Gold Creek, and wetlands. Gradient drops quickly to less than five percent. The majority of the upper tributaries flow through glacial till that is moderately erodible. The river actively meanders, depositing much of the sediment load on sand and gravel bars. Minor bank erosion is a natural occurrence with this type of stream morphology. The mouth of the river is a broad alluvial valley (Puget Sound Cooperative River Basin Team 1991). Logging has been the dominant land use in the Tahuya Watershed both historically and at the present time. The Tahuya State Forest and private lands are currently managed for timber production (Ames *et al.* 2000). An off-road vehicle (ORV) trail system is located on the state forest (Hood Canal Coordinating Council 2002).

Lower Tahuya River Subwatershed — mouth to Unnamed Stream 15.0453 (RM 6.7)

Habitat Ratings

Access and Passage

Artificial Barriers
Two complete barrier culverts and two partial barrier culverts are present on tributaries to this reach of the Tahuya River (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity
Residential and agricultural development on the floodplain from RM 7.5 downstream have degraded habitat through vegetation removal, diking, and bank armoring (Ames *et al.* 2000). A large horse farm is located on the middle of the floodplain near RM 2.0. The river splits into two channels at the upper end of the farm. A dike about one half-mile in length forces flows to remain in the narrow west channel. The east channel is only active during high flows. A large logjam at the upper end of the farm appears to be poised to cause an avulsion, sending the main flow of the river into the east channel. A similar avulsion occurred downstream in 2001-2002 (Ereth 2003, Personal communication). May and Peterson (2002) rated floodplain conditions on the lower mile of the Tahuya fair (25 to 50% lost connectivity), and good (<25% lost connectivity) from RM 1.0 to RM 8.0. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat
May and Peterson rated floodplain conditions on the lower mile of the Tahuya fair (25 to 50% lost floodplain habitat), and good (<25% lost floodplain habitat) from RM 1.0 to RM 8.0. Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment
Off-road vehicle trails and stream crossings on the Tahuya State Forest are a major source of sediment entering the Tahuya River and its tributaries. Maintained trails and bridges do not cause problems, but illegal trails and crossings are the primary source of sediment entering the stream. Crossings are typically located at riffles, the same areas where salmonids spawn. Many developing eggs and juveniles may be killed by the illegal crossing activity (Puget Sound Cooperative River Basin Team 1991). In 1994, 13 substrate samples were collected on the Tahuya River from RM 4.1 to RM 7.4. Fine sediment levels (less than 0.85 mm) ranged from 3 to 17% (mean 10.5%). Gravel

comprised 79% of the substrate (Bernthal and Rot 2001). May and Peterson (2002) rated fine sediment throughout the Tahuya River Watershed optimal (<10% fines). Fine sediment was rated good to fair.

Large Woody Debris

The WDF SID operated in the Tahuya River Watershed from 1955 to 1970. In 1955, an unspecified number of logjams were removed from the mainstem. In 1958, a logjam was removed on the Tahuya. From 1962 to 1970, numerous logjams and beaver dams were removed from the mainstem of the Tahuya (Amato 1996). Between RM 4.1 and 7.4 on the mainstem Tahuya, woody debris abundance was 0.5 pieces per channel width. Key piece abundance was 0.04 pieces per channel width. The majority of LWD (91%) was within the bankfull channel. Only 23% of LWD pieces were unstable (Bernthal and Rot 2001). Woody debris was abundant in the lower mainstem Tahuya River with 3.47 pieces per channel width. Key piece abundance was 0.77 pieces per channel width (Hood Canal Salmon Enhancement Group 2003, Unpublished work). See Table 5 for LWD abundance in tributary streams in the Lower Tahuya Subwatershed. Large woody debris was rated good on the lower mainstem Tahuya River and poor on the tributaries identified below.

Table 5. Lower Tahuya River Subwatershed LWD Abundance.

Stream Name	Stream No.	Survey Length (meters)	LWD Total Pieces/ Channel Width (% conifer)	LWD Key Pieces (>0.50 meters) per Channel Width
Lower Tahuya River (RM 0.0 to RM 6.7)	15.0446	10,000	3.47 (39%)	0.77
Schoolhouse Creek	15.0447	2,500	0.96 (ND)	0.10
Howell Lake Outlet	15.0449	3,000	1.01 (ND)	0.09

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. ND = No data.

Percent Pools

The HCSEG inventoried pool surface area on streams within the lower Tahuya River Subwatershed in the late 1990s. Pools comprised a mean 66.5% of stream surface area on the mainstem lower Tahuya River. Pool surface areas of tributary streams are summarized in Table 6 (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Percent pools were rated good on the lower Tahuya mainstem and poor on the tributaries identified in the table below.

Table 6. Lower Tahuya River Subwatershed Pool Surface Area.

Stream Name	Stream No.	Survey Length (meters)	Mean Percent Pool Surface Area
Lower Tahuya River (RM 0.0 to RM 6.7)	15.0466	10,000	66.5
Schoolhouse Creek	15.0447	3,000	31.3
Howell Lake Outlet	15.0449	2,000	16.1

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. ND = No data.

Pool Frequency

From RM 4.1 to RM 7.4, pool frequency was 2.5 channel widths per pool (Bernthal and Rot 2001). Pool frequency was rated fair.

Pool Quality

From RM 4.1 to RM 7.4 on the Tahuya mainstem, 46% of pools had a residual depth 0.5 to 1.0 meter deep. Residual pool depth greater than 1.0 meter deep was present in 38% of pools. Pools with residual depths less than 0.5 meter comprised 17% of the samples. Debris jams and logs were the most common pool forming agents (Bernthal and Rot 2001). May and Peterson (2002) rated pool quality on the mainstem Tahuya River good, indicating some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

The WDF SID channelized portions of the Tahuya River and an unnamed tributary in the late 1960s (Amato 1996). Roads, agriculture, and residential development have affected approximately 50% of the lower three miles of the Tahuya River. Development has led to conflicts between natural channel processes and protection of property through bank armoring, flood protection, and LWD removal (Ames *et al.* 2000). May and Peterson (2002) rated streambank stability on the lower mile of the Tahuya fair (50 to 75% stable banks). They rated streambank stability from RM 1.0 to RM 8.0 good (75 to 90% stable banks). Streambank stability was rated fair to poor.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Lower Tahuya River Subwatershed was 4.7 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Forests and clearcuts cover 71% and 6% of the riparian zone respectively. Agriculture, primarily Christmas tree farms and other small farms occupy 8% of the riparian corridor. Residential development covers 12% of the riparian zone. Along the lower nine miles of the Tahuya River, 29% of the riparian buffer is sparsely vegetated or less than 66 feet wide. Deciduous trees represent 52% of the riparian forest, a mix of coniferous and deciduous trees comprise 37% of the buffer. The majority of the riparian forest is composed of young trees (93% <20 inches dbh) that do not provide adequate LWD recruitment (Ames *et al.* 2000). In 1994, from RM 4.1 to RM 7.4 the riparian buffer was dominated by immature deciduous vegetation. Canopy closure was only 39% (Bernthal and Rot 2001). Riparian buffer ratings from May and Peterson (2002) correspond to a moderately wide riparian buffer somewhat impacted by development. The buffer is composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating for this reach ranged from 3.3 to 3.0. Riparian condition was rated fair.

Water Quality

Temperature

During the summer of 1994, water temperatures at RM 5.3 of the Tahuya mainstem exceeded 16ºC 15 times and exceeded 14ºC 33 times from July 1 to August 2. Water temperatures upstream at RM 7.4 exceeded 16ºC every one of the 16 days measured from mid-July to August (Bernthal and Rot 2001). During the summer of 1995, water temperatures at RM 1.0 of the Tahuya River exceeded 16ºC 14 times and exceeded 14ºC each of the 28 days temperatures were measured (7/31-8/27). Upstream at RM 2.3, the Class AA standard of 16ºC was exceeded only 5 times, but 14ºC was exceeded all 28 days measurements were taken (7/31-8/27) (Bernthal and Rot 2001). The Skokomish Tribe monitored temperatures at RM 1.0 in the summer of 1996. Temperatures exceeded 14ºC for 45 consecutive days and 16.3ºC on 32 days. The maximum recorded temperature was 19.3ºC. Temperatures were monitored at the same location in the summer of 1997. Temperatures exceeded 14ºC for 61 consecutive days and exceeded 16.3ºC 49 times (29 consecutive days). The maximum temperature recorded was 19.4ºC (Ereth 2003, Personal communication). Temperature was rated fair.

Dissolved Oxygen

No information was available.

Hydrology

Flow gages were operated at several locations in the Tahuya River Watershed from 1945 to 1956 (Garling and Molenaar 1965). No recent flow records are known to exist. The middle reach of the Tahuya River loses surface flow to the water table. The loss is significant enough that flows are intermittent in some areas. Some of the flow reappears as surface water downstream, but it is believed that sizable quantities of water migrate through the ground and contribute flow to nearby streams. The Dewatto River is believed to be a recipient of some of this water (Garling and Molenaar 1965). Many of the smaller tributaries go dry early in the summer as well as during winter dry spells (Ames *et al.* 2000). The Tahuya River is closed to additional consumptive appropriations from June 15 to October 15 (State of Washington 1988). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

Middle Tahuya River Subwatershed — RM 6.7 to Bear Creek Dewatto Road (RM 16.3)

Habitat Ratings

Access and Passage

Artificial Barriers

Nine complete barrier culverts are present on tributaries of this reach. A weir and two additional culverts are partial barriers (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

Residential and agricultural development on the floodplain from RM 7.5 downstream have degraded habitat through vegetation removal, diking, and bank armoring (Ames *et al.* 2000). May and Peterson (2002) rated floodplain conditions from RM 8.0 to RM 16.0 optimal (natural floodplain function). Floodplain connectivity was rated good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions from RM 8.0 to RM 16.0 optimal (natural floodplain function). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

Off-road vehicle trails in the Tahuya State Forest and stream crossings are a major source of sediment entering the Tahuya River and its tributaries. Maintained trails and bridges do not cause problems, but illegal trails and crossings are the primary source of sediment entering the stream. Crossings are typically located at riffles, the same areas where salmonids spawn. Many developing eggs and juveniles may be killed by the illegal crossing activity (Puget Sound Cooperative River Basin Team 1991). Supplemental surveys conducted in the late 1980s by the WDF on the Little Tahuya River reported gravel comprising 80% of substrate from the mouth to RM 1.9 and 65% of substrate from RM 1.9 to RM 2.5. Sand comprised 90% of substrate from RM 2.5 to RM 4.3 (Baranski 1989, Unpublished work). May and Peterson (2002) rated fine sediment optimal (<10% fines) for the entire Tahuya River Watershed. Fine sediment was rated good to fair.

Large Woody Debris

The WDF SID operated in the Tahuya River Watershed from 1955 to 1970. In 1955, an unspecified number of logjams were removed from the mainstem. In 1958, Erdman Lake Creek (15.0459) was cleared and a logjam was removed on the Tahuya (Amato 1996). Woody debris abundance was 0.15 pieces per meter (Ames *et al.* 2000). Large woody debris was abundant on the middle reach of the mainstem Tahuya River with 3.16 pieces per channel width. Key piece abundance was 0.77 pieces per channel width. The Little Tahuya River and Haven Lake Outlet Creek also had an abundance of LWD (Hood Canal Salmon Enhancement Group 2003, Unpublished work). See Table 7 for LWD abundance in other streams in the Middle Tahuya Watershed. Large woody debris was rated good on the middle Tahuya River mainstem, the Little Tahuya River, and Haven Lake Outlet. Large woody debris on the other tributaries identified below was rated fair to poor.

Table 7. Middle Tahuya River Subwatershed LWD Abundance.

Stream Name	Stream No.	Survey Length (meters)	LWD Total Pieces/ Channel Width (% conifer)	LWD Key Pieces (>0.50 meters) per Channel Width
Middle Tahuya River (RM 6.7 to RM 16.3)	15.0446	10,000	3.16 (42%)	0.77
Potholes Tributary	15.0454	500	0.19 (ND)	0.00
South Spillman Creek	15.0456	1,000	0.35 (ND)	0.03
Little Tahuya	15.0457	500	4.16 (ND)	0.59
Long Marsh Outlet	15.0491*	500	1.09 (ND)	0.07
Andy's Creek	15.0458	500	0.04 (19%)	0.00
Erdman Lake Outlet	15.0459	2,500	0.44 (ND)	0.01
Christine Lake Outlet	15.0460	500	1.01 (ND)	0.17
Haven Lake Outlet	15.0461	2,000	3.75 (ND)	0.54
Christine Lake Inlet	15.0464	2,500	0.67 (ND)	0.08
Unnamed Stream	15.0465	2,000	1.39 (ND)	0.41
Blacksmith Lake Outlet	15.0468	1,000	0.19 (ND)	0.08

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. *Stream #15.0491 is mapped by Williams *et al.* (1975) as a tributary of Stimson Creek. However, this stream is a tributary of stream #15.0457.

Percent Pools

The HCSEG inventoried pool surface area on the middle Tahuya River and several tributary streams in the late 1990s. Pools comprised a mean 61.3% of stream surface on the mainstem middle Tahuya River. Pool surface areas on tributaries of this reach are summarized in Table 8 (Hood Canal Salmon Enhancement Group 2003, Unpublished work). In the late 1980s, WDF conducted supplemental stream surveys from the mouth of the Little Tahuya River upstream to RM 4.1. They reported 74% pools from the mouth to RM 2.5, and 100% pools from RM 2.5 to RM 4.1 (Baranski 1989, Unpublished work). Percent pools were rated good for this entire subwatershed.

Table 8. Middle Tahuya River Subwatershed Pool Surface Area.

Stream Name	Stream No.	Survey Length (meters)	Mean Percent Pool Surface Area
Middle Tahuya River (RM 6.7 to RM 16.3)	15.0446	14,000	61.3
Potholes Tributary	15.0454	500	60.9
South Spillman Creek	15.0456	1,000	39.2
Little Tahuya River	15.0457	5,000	69.0
Long Marsh Outlet	15.0491*	500	38.5
Andy's Creek	15.0458	500	87.2
Erdman Lake Outlet	15.0459	2,500	63.3
Christine Lake Outlet	15.0460	500	29.9
Haven Lake Outlet	15.0461	2,500	45.6
Christine Lake Inlet	15.0464	2,500	56.6
Unnamed Stream	15.0465	2,000	96.8
Blacksmith Lake Outlet	15.0468	1,500	53.8

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. ND = No data. *Stream #15.0491 is mapped by Williams *et al.* (1975) as a tributary of Stimson Creek. However, this stream is a tributary of stream #15.0457.

Pool Frequency

Pool frequency was 2.4 channel widths per pool (Ames *et al.* 2000). Pool frequency was rated fair.

Pool Quality

May and Peterson (2002) rated pool quality on the mainstem Tahuya River good, while all tributaries were rated optimal. These ratings indicate that some deep pools with cover are present on the middle Tahuya mainstem, while deep pools with cover are abundant on the tributaries. Pool quality was rated good.

Streambank Stability

The WDF SID channelized portions of the Tahuya River and an unnamed tributary in the late 1960s (Amato 1996). May and Peterson (2002) rated streambank stability throughout this subwatershed optimal (>90% stable banks). Streambank stability was rated good.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Middle Tahuya River Subwatershed was 4.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Forests and clearcuts cover 71% and 6% of the riparian zone respectively. Agriculture, primarily Christmas tree farms and other small farms occupy 8% of the riparian corridor. Residential development covers 12% of the riparian zone. Along the lower nine miles of the Tahuya River, 29% of the riparian buffer is sparsely vegetated or less than 66 feet wide. Deciduous trees represent 52% of the riparian forest. A mix of coniferous and deciduous trees comprise 37% of the buffer. The majority of the riparian forest is composed of young trees (93% <20 inches dbh) that do not provide adequate LWD recruitment (Ames *et al.* 2000). Riparian habitat ratings in May and Peterson (2002) indicate that riparian buffers in this subwatershed are wide, intact and composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

Temperature

Water temperatures at RM 0.1 of the Little Tahuya River did not exceed the state AA water quality standard of 16ºC during the summer of 1994. However, water temperatures did exceed the maximum preferred juvenile salmonid rearing temperature of 14ºC ten times during late July. The Skokomish Tribe monitored water temperatures at RM 11.7 of the Tahuya River in the summer of 1996. Temperatures exceeded 14°C on 35 of the 46 days of monitoring. Temperatures exceeded 16.3°C only for times. The maximum temperature recorded was 16.7°C (Ereth 2003, Personal communication). Temperature was rated fair to good.

Dissolved Oxygen

No information was available.

Hydrology

Flow gages were operated at several locations in the Tahuya River Watershed from 1945 to 1956 (Garling and Molenaar 1965). No recent flow records are known to exist. The middle reach of the Tahuya River loses surface flow to the water table. The loss is significant enough that flows are intermittent in some areas. Some of the flow reappears as surface water downstream, but it is believed that sizable quantities of water migrate through the ground and contribute flow to nearby streams. The Dewatto River is believed to be a recipient of some of this water (Garling and Molenaar 1965). Many of the smaller tributaries go dry early in the summer as well as during winter dry spells (Ames *et al.* 2000). The Tahuya River is closed to additional consumptive appropriations from June 15 to October 15 (State of Washington 1988). Flows above RM 4.1 on the Little Tahuya River get very low during the summer months. In the late 1980s, the estimated summer flow from the mouth to RM 4.1 was 0.9 cfs (Baranski 1989, Unpublished work). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

Upper Tahuya River Subwatershed — Bear Creek Dewatto Road (RM 16.3) to Headwaters

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at RM 0.15 of Grata Creek was a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. This culvert was replaced in the summer of 2001 by Kitsap Storm and Surface Water Management (Ereth 2003, Personal communication). Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions optimal (natural floodplain function) on the upper Tahuya River mainstem and good (<25% lost connectivity) on tributaries in this subwatershed. Floodplain connectivity was rated good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions optimal (natural floodplain function) on the upper Tahuya River mainstem and good (<25% lost floodplain habitat) on tributaries in this subwatershed. Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment optimal (<10% fines) throughout the entire Tahuya River Watershed. Fine sediment was rated good.

Large Woody Debris

The WDF SID operated in the Tahuya River Watershed from 1955 to 1970. From 1962 to 1970, numerous logjams and beaver dams were removed from the mainstem Tahuya and Grata, Gold, and Tin Mine Creeks (Amato 1996). Woody debris was abundant in the lower portion of Morgan Marsh Outlet Creek (15.0471), with a total piece abundance of 2.54 pieces per channel width. No key pieces were identified (Hood Canal Salmon Enhancement Group 2003, Unpublished work). May and Peterson (2002) rated LWD quantity good in this subwatershed. This corresponds to moderate LWD abundance. Large woody debris was rated fair.

Percent Pools

The HCSEG inventoried pool surface area in the upper Tahuya River Subwatershed in the late 1990s. Pools comprised a mean 81.9% of stream surface area on the upper mainstem Tahuya River. Pool surface areas of tributary streams are summarized in Table 9 (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Percent pools were rated good for this entire subwatershed.

Table 9. Upper Tahuya River Subwatershed Pool Surface Area.

Stream Name	Stream No.	Survey Length (meters)	Mean Percent Pool Surface Area
Upper Tahuya River (RM 16.3 to Source)	15.0446	11,000	81.9
Morgan Marsh Outlet	15.0471	1,000	69.0
Grata Creek	15.0475	1,000	43.3
Tin Mine Creek	15.0476	1,000	69.7

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. ND = No data.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality on the entire Tahuya River mainstem good. Pool quality on all tributaries was rated optimal. These ratings indicate that some deep pools with cover are present on the mainstem, while deep pools with cover are abundant on the tributaries. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability in this subwatershed optimal (>90% stable banks). Streambank stability was rated good.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Upper Tahuya River Subwatershed was 3.9 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) indicate that riparian buffers in this subwatershed are wide, intact and composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

Temperature

The Skokomish Tribe monitored water temperatures about 1,000 feet downstream from Lake Tahuya in the summer of 1996. Temperatures exceeded 14°C for 50 consecutive days and exceeded 16.3°C on 43 of 50 days. Temperatures exceeded 20°C on 14 days. The maximum temperature recorded was 25°C. Temperatures dropped below 14°C on only five of the days in the monitoring period (Ereth 2003, Personal communication). Temperature was rated poor.

Dissolved Oxygen

No information was available.

Hydrology

Flow gages were operated at several locations in the Tahuya River Watershed from 1945 to 1956 (Garling and Molenaar 1965). No recent flow records are known to exist. Many of the smaller tributaries go dry early in the summer as well as during winter dry spells (Ames *et al.* 2000). The Tahuya River is closed to additional consumptive appropriations from June 15 to October 15 (State of Washington 1988). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No information was available to assess biological processes.

UNION-MISSION SUBBASIN HABITAT LIMITING FACTORS

Subbasin Description

The Union-Mission Subbasin drains 59 square miles of land from the Tahuya River Watershed east to the boundary of west WRIA 15. See Map 6. The Union River and Big Mission Creek are the largest streams within this subbasin. The community of Belfair in the lower Union River Watershed is the largest population center in the subbasin. Dense residential development is concentrated along Northshore Road on the Hood Canal shoreline. Descriptions of individual watersheds are located in the habitat description of each stream.

Shoofly Creek (15.0478) Watershed

Description

Shoofly Creek enters Hood Canal about 3.5 miles east of Sisters Point. The stream is 1.5 miles long with several small tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

Below Northshore Road, Shoofly Creek is channelized through a filled and developed residential area (Washington Department of Ecology 2000b). See oblique photo #145950. The stream is dredged to maintain channel capacity (TAG 2003). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Home construction along the lower portion of Shoofly Creek has constrained the channel, reducing floodplain connectivity. The stream carries a high sediment load that is deposited during low flow conditions. Normally the stream would cut new channels by meandering across the delta. However, since the stream is no longer able to meander across the delta, sediment is deposited in the channel, causing aggradation and flooding (Puget Sound Cooperative River Basin Team 1991). Loss of floodplain habitat was rated poor.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

In 1970, the WDF SID cleared woody debris from Shoofly Creek (Amato 1996). May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

The WDF SID channelized Shoofly Creek in 1970 (Amato 1996). The stream is actively downcutting through the glacial advance outwash sediments deposited in this area. The stream erodes and transports relatively large amounts of sediment downstream where it is deposited at the mouth (Puget Sound Cooperative River Basin Team 1991). May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Shoofly Creek Watershed was 4.4 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) are indicative of a moderately wide riparian buffer composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

No water quality information was available.

Hydrology

Flow in Shoofly Creek is largely dependent upon groundwater. As groundwater withdrawals increase, flows decrease, particularly during dry weather (Puget Sound Cooperative River Basin Team 1991). During low flow conditions the stream is not able to transport its sediment load and the channel subsequently aggrades. Sand and gravel have accumulated in the lower reach, causing flooding near the mouth. Under natural conditions, the stream would cut a new channel through the delta, but home development has constrained channel migration in the lower stream reach (Puget Sound Cooperative River Basin Team 1991). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No biological processes information was available.

Little Shoofly Creek (15.0483) Watershed

Description

Little Shoofly Creek enters Hood Canal about one mile east of Shoofly Creek. The stream is about 0.8 miles in length with about 1.5 miles of tributaries (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to exist in the Little Shoofly Creek Watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

Home construction along the lower portion of Little Shoofly Creek has constrained the channel, reducing floodplain connectivity (Puget Sound Cooperative River Basin Team 1991). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Home construction along the lower portion of Little Shoofly Creek has constrained the channel, reducing floodplain connectivity. The stream carries a high sediment load that is deposited during low flow conditions. Normally the stream would cut new channels by meandering across the delta. However, since the stream is no longer able to meander across the delta, sediment is deposited in the channel, causing aggradation and flooding (Puget Sound Cooperative River Basin Team 1991). Loss of floodplain habitat was rated poor.

<u>Channel Conditions</u>

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

<u>Sediment Input</u>

Sediment Supply

Little Shoofly Creek is actively downcutting through the glacial advance outwash sediments deposited in this area. The stream erodes and transports relatively large amounts of sediment downstream where it is deposited at the mouth (Puget Sound Cooperative River Basin Team 1991).

Mass Wasting

No information was available.

Road Density

Road density in the Little Shoofly Creek Watershed was 4.6 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) correspond to a moderately wide riparian buffer composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality

No water quality information was available.

Hydrology

Flow is largely dependent upon groundwater. As groundwater withdrawals increase, flows decrease, particularly during dry weather (Puget Sound Cooperative River Basin Team 1991). During low flow conditions the stream is not able to transport its sediment load and the channel subsequently aggrades. Sand and gravel have accumulated in the lower reach, causing flooding near the mouth. Under natural conditions, the stream would cut a new channel through the delta, but home development has constrained channel migration in the lower reach (Puget Sound Cooperative River Basin Team 1991). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No biological processes information was available.

Cady Creek (15.0486) Watershed

Description

Cady Creek enters Hood Canal about 1.3 miles east of Little Shoofly Creek. The mainstem is about one mile in length (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in the Cady Creek Watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

<u>Channel Conditions</u>

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Cady Creek Watershed was 1.5 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated good.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) correspond to a moderately wide riparian buffer composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating was 3.3. Riparian condition was rated fair.

Water Quality
No water quality information was available.

Hydrology
No hydrology information was available.

Biological Processes
No biological processes information was available.

Northshore Nursery Creek (15.0487) Watershed

Description
Northshore Nursery Creek enters Hood Canal about one half-mile east of Cady Creek. The mainstem is about one mile in length (Williams *et al.* 1975).

Habitat Ratings

Access and Passage

Artificial Barriers
A culvert at RM 0.15 is a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated poor.

Floodplains
No floodplain information was available.

Channel Conditions
No channel conditions information was available.

Sediment Input
No information was available to assess sediment supply or mass wasting.

Road Density
Road density in the Northshore Nursery Creek Watershed was 4.2 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition
No information was available.

Water Quality
No water quality information was available.

Hydrology
No hydrology information was available.

Biological Processes
No biological processes information was available.

Stimson Creek (15.0488) Watershed

Description
Stimson Creek enters Hood Canal about 0.8 miles west of Sunbeach (Williams *et al.* 1975). The stream drains about 2.3 square miles of land and is about 5.3 miles in length (Hood Canal Coordinating Council 2002). The creek flows through a steep wooded ravine that it shares with Elfendahl Pass Road (Puget Sound Cooperative River Basin Team 1991).

Habitat Ratings

Access and Passage

Artificial Barriers
A culvert at RM 1.3 was a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. The HCSEG recently replaced this culvert. Coho salmon were observed above the new culvert in the fall of 2002. A culvert at the Elfendahl Pass Road crossing of a right bank tributary immediately downstream from the new culvert is a partial barrier with a two-foot drop at the outfall. Adult and juvenile coho have been observed above this culvert (Ereth 2003, Personal communication). Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity
May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity). This loss of connectivity is presumably caused by Elfendahl Pass Road, which parallels much of the length of the stream. Floodplain connectivity was rated fair.

Loss of Floodplain Habitat
May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat). Loss of floodplain habitat was rated fair.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

The WDF SID removed an unspecified number of logjams from Stimson Creek in 1965 and 1970 (Amato 1996). May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Stimson Creek Watershed was 4.2 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) correspond to a narrow and fragmented riparian buffer composed of a mix of mature and immature coniferous trees. Degradation of the buffer is presumably caused by the close proximity of Elfendahl Pass Road to Stimson Creek. The mean riparian condition rating was 3.0. Riparian condition was rated fair.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

Sundstrom Creek (15.0492) Watershed

Description

Sundstrom Creek enters Hood Canal about 0.9 of a mile east of Stimson Creek (Williams *et al.* 1975). Land cover is dominated by rural residential development and state timberlands (Hood Canal Coordinating Council 2002).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in the Sundstrom Creek Watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity). Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat). Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment good (10 to 15% fines). Fine sediment was rated fair to good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, indicating moderate abundance. Large woody debris abundance was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools fair (20 to 30% pools). Percent pools were rated poor.

Pool Frequency
No information was available.

Pool Quality
May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability
May and Peterson (2002) rated streambank stability good (75 to 90% stable banks). Streambank stability was rated fair.

Sediment Input
No information was available to assess sediment supply or mass wasting.

Road Density
Road density in the Sundstrom Creek Watershed was 5.9 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition
Riparian habitat ratings in May and Peterson (2002) describe a narrow, fragmented buffer composed of a mix of mature and immature coniferous trees. The mean riparian condition rating was 3.0. Riparian condition was rated fair.

Water Quality
No water quality information was available.

Hydrology
No hydrology information was available.

Biological Processes
No biological processes information was available.

Little Mission Creek (15.0493) Watershed

Description

Little Mission Creek enters Hood Canal at Belfair State Park, about 0.3 of a mile west of Big Mission Creek. During low flow periods, Little Mission Creek carries surprisingly high flows for a stream of this size (Williams *et al.* 1975). The Little Mission Creek Watershed contains about 4.2 miles of stream channel, equally distributed among the mainstem and tributaries. Rural residential development and state timberlands are the dominant land cover (Hood Canal Coordinating Council 2002). Little Mission Creek flows through a gently sloping valley with moderate gradient. Above Belfair State Park, a short reach flows through a highly residential area, but the upper watershed is nearly entirely forested (Puget Sound Cooperative River Basin Team 1991).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at RM 0.15 of stream 15.0494 is a complete barrier (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions good (<25% lost connectivity) on the lower half-mile of stream and optimal (natural floodplain function) on the remainder of the mainstem. Floodplain connectivity was rated fair to good.

Loss of Floodplain Habitat

Little Mission Creek is channelized on the reach that flows through Belfair State Park (TAG 2003). May and Peterson (2002) rated floodplain conditions good (<25% lost floodplain habitat) on the lower half-mile of stream and optimal (natural floodplain function) on the remainder of the mainstem. Loss of floodplain habitat was rated good.

Channel Conditions

Fine Sediment

May and Peterson (2002) rated fine sediment optimal (<10% fines). Fine sediment was rated good.

Large Woody Debris

May and Peterson (2002) rated LWD quantity good, corresponding to moderate abundance. Large woody debris was rated fair.

Percent Pools

May and Peterson (2002) rated percent pools good (30 to 40% pools). Percent pools were rated fair.

Pool Frequency

No information was available.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability optimal (>90% stable). Streambank stability was rated good.

<u>Sediment Input</u>

Sediment Supply

Aggradation is taking place in the channelized reach through Belfair State Park. The channel requires annual dredging to maintain channel capacity (TAG 2003). No additional information was available.

Mass Wasting

No information was available.

Road Density

Road density in the Little Mission Creek Watershed was 2.9 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

<u>Riparian Zones</u>

Riparian Condition

Riparian habitat ratings in May and Peterson (2002) correspond to a wide, intact riparian buffer composed of mature stands of conifers and mixed stands of coniferous and deciduous trees. The mean riparian condition rating ranged from 4.0 on the lower half-mile of stream to 3.7 on the remainder of the stream. Riparian condition was rated good to fair.

<u>Water Quality</u>

No water quality information was available.

<u>Hydrology</u>

No hydrology information was available.

Biological Processes

No biological processes information was available.

Big Mission Creek (15.0495) Watershed

Description

Big Mission Creek enters Hood Canal at Plum Point, about two miles west of the Union River and three miles west of the city of Belfair (Puget Sound Cooperative River Basin Team 1991). The stream drains about 13.7 square miles of land. The watershed contains about 20 miles of stream channel, equally distributed between the mainstem and tributaries (Hood Canal Coordinating Council 2002). Big Mission Creek begins in a forest above Mission Lake and wetlands northwest of Mission Lake. The channels merge downstream of the Mission Lake outlet. Gradient throughout the length of the stream is generally less than five percent. The watershed is characterized by glacial sediments that are highly erodible (Puget Sound Cooperative River Basin Team 1991). The upper and middle reaches of the watershed are industrial forests managed by the DNR and other land owners (Ames *et al.* 2000).

Habitat Ratings

Access and Passage

Artificial Barriers

Two culverts are complete barriers on tributaries of Big Mission Creek. These barriers block a small amount of habitat in relation to the size of the watershed. A partial barrier is located just downstream from the outlet of Mission Lake (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

A dike at Belfair State Park and a road have eliminated floodplain connectivity on the lower 0.2 miles of Big Mission Creek (Washington Department of Ecology 2000b). May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity) on the lower half-mile of stream and good (<25% lost connectivity) from RM 0.5 to the headwaters. Floodplain connectivity was rated fair on the lower half-mile of stream and fair to good on the remainder of Big Mission Creek.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat) on the lower half-mile of stream and good (<25% lost floodplain habitat) from RM 0.5 to the headwaters. Loss of floodplain habitat was rated fair on the lower half-mile of stream and good on the remainder of Big Mission Creek.

Channel Conditions

Fine Sediment

In the late 1980s, gravel was the dominant substrate in Big Mission Creek from the mouth to RM 7.4. Gravel abundance increased as one progressed upstream (Baranski 1989, Unpublished work). May and Peterson (2002) rated fined sediment optimal (<10% fines) throughout the mainstem of Big Mission Creek. Fine sediment was rated good.

Large Woody Debris

In 1966-67 and 1969, the WDF SID removed logjams from Big Mission Creek (Amato 1996). From the mouth to RM 1.5, large woody debris abundance was 0.07 pieces per meter. Woody debris was more common upstream. Channel clean-outs are a continuing problem associated with development along Big Mission Creek. Lack of instream habitat complexity is believed to have a significant adverse impact on chum production (Ames *et al.* 2000). May and Peterson (2002) rated LWD quantity good throughout the mainstem of Big Mission Creek, indicating moderate abundance. Large woody debris was rated fair.

Percent Pools

Surveys conducted by the WDF in the late 1980s reported 37% pools from the mouth to RM 3.9 and 62% pools from RM 3.9 to RM 7.4 (Baranski 1989, Unpublished work). May and Peterson (2002) rated percent pools good (30 to 40% pools). Percent pools were rated fair to good.

Pool Frequency

From the mouth to RM 1.5, pool frequency was 6.5 channel widths per pool (Ames *et al.* 2000). Pool frequency was rated poor.

Pool Quality

May and Peterson (2002) rated pool quality good, indicating that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

From 1966-67, the WDF SID channelized four miles of the stream channel (Amato 1996). Bank armoring is a continuing problem associated with development along Big Mission Creek (Ames *et al.* 2000). May and Peterson (2002) rated bank stability good (75 to 90% stable banks) on the lower half-mile of stream, and optimal (>90% stable banks) from RM 0.5 to the headwaters. Streambank stability was rated good to poor.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Big Mission Creek Watershed was 4.0 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

The lower two miles of stream have several county road crossings. The riparian zone on this reach has been heavily developed as home sites. The riparian zone along the lower 1.5 miles of Big Mission Creek was composed of 70% forest and 30% development and roads. The forest was dominated by deciduous vegetation (98%). Trees less than 12 inches dbh comprised 36% of the forest. Forty-five percent of the length of the buffer was either sparse or less than 66 feet wide. The current riparian forest does not provide the LWD needed to maintain channel stability. Riparian logging is a continuing problem associated with development along Big Mission Creek (Ames *et al.* 2000). Riparian habitat ratings in May and Peterson (2002) correspond to a narrow and fragmented buffer composed of an immature forest of coniferous and deciduous trees on the lower half-mile of stream. From RM 0.5 upstream, the buffer is moderately wide and composed of a mix of mature and immature coniferous and deciduous trees. The mean riparian condition rating for the lower half-mile of stream was 2.3. The mean rating for the remainder of the watershed was 3.0. Riparian condition was rated fair to poor on the lower half-mile of stream and fair along the remainder of the mainstem.

Water Quality

No water quality information was available.

Hydrology

The WDF conducted supplemental surveys on Big Mission Creek in the late 1980s from the mouth upstream to RM 7.4. The following estimated summer flows were calculated from these surveys: mouth to RM 3.0 (7.4 cfs), RM 3.0 to 4.3 (6.3 cfs), RM 4.3 to 5.5 (2.0 cfs), RM 5.5 to 7.4 (1.1 cfs). The stream goes dry above RM 7.4 during low flow periods (Baranski 1989, Unpublished work). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

No biological processes information was available.

Union River (15.0503) Watershed

Description

The Union River enters Lynch Cove at the terminus of the east arm of Hood Canal. The river drains approximately 24 square miles of land. The mainstem is 10 miles in length with 30 miles of tributaries (Ames *et al.* 2000). The river originates in the Blue Hills at about 1,500 feet elevation. From the outlet of Union River Reservoir upstream the river flows through an undeveloped watershed (with restricted entry to protect water quality). The reservoir, completed in 1957, was created to supply up to five million-gallons of water per day for municipal and industrial use by the City of Bremerton and the Puget Sound Naval Shipyard (Williams *et al.* 1975, cited in Ames *et al.* 2000). Land use in the upper portion of the Union River Watershed is dominated by industrial forestry and water storage/diversion. Moderately heavy residential development, numerous small hobby farms, and minor forestry operations are the principal land uses along the middle and lower reaches (Williams *et al.* 1975, Puget Sound Cooperative River Basin Team 1991). The city of Belfair is located directly east of the river mouth (Ames *et al.* 2000).

Habitat Ratings

Access and Passage

Artificial Barriers

Four culverts are complete barriers on stream 15.0512. Complete barrier culverts are also present on streams 15.0507 and 15.0503E (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). These barriers block a small amount of habitat in relation to the size of the watershed as a whole. See Map 26. Artificial barriers were rated fair.

Floodplains

Floodplain Connectivity

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost connectivity) on the lower mile of the Union River and good (<25% lost connectivity) on the remainder of the mainstem and Courtney, Bear, Airport, and Hazel Creeks. Floodplain connectivity was rated fair on the lower mile of the Union river, and fair to good on the remainder of the Union River and the tributaries identified above.

Loss of Floodplain Habitat

May and Peterson (2002) rated floodplain conditions fair (25 to 50% lost floodplain habitat) on the lower mile of the Union River and good (<25% lost floodplain habitat) on the remainder of the mainstem and Courtney, Bear, Airport, and Hazel Creeks. Loss of floodplain habitat was rated fair on the lower mile of the Union river, and good on the remainder of the Union River and the tributaries identified above.

Channel Conditions

Fine Sediment

According to WDF surveys conducted in the late 1980s, gravel comprised more than 75% of substrate on the lower 2.4 miles of Courtney Creek. Gravel comprised 80% of substrate on the lower 1.85 miles of Bear Creek (Baranski 1989, Unpublished work). May and Peterson (2002) rated fine sediment good (10 to 15% fines) on the mainstem Union River and Courtney, Bear, Airport, and Hazel Creeks. Fine sediment was rated fair to good.

Large Woody Debris

Stream clean outs and riparian logging have led to low key LWD piece abundance. Stream clean-outs have occurred since the 1800s, but were more intensive in the late 1960s (Ames *et al.* 2000). The WDF SID removed logjams from Courtney Creek in 1967. In 1968, five logjams and debris were removed from the Union River and a five mile reach was channelized. An unspecified number of logjams were removed from Courtney Creek the same year. In 1970, woody debris was removed from Courtney and Bear Creeks (Amato 1996). Habitat surveys conducted in 1993 by the PNPTC found a mean abundance of 0.22 pieces of LWD per meter from the mouth to McKenna Falls. Almost 42% of the wood was small (10 to 20 cm diameter). Much of the LWD was western redcedar (Ames *et al.* 2000). Surveys conducted by HCSEG found 1.96 pieces of LWD per channel width and 0.39 key pieces per channel width on the mainstem Union River (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Woody debris abundance values on several tributaries of the Union River are found in Table 10. May and Peterson (2002) rated LWD quantity good on the Union River and Courtney, Bear, Airport, and Hazel Creeks. This rating indicates moderate LWD abundance. Large woody debris was rated fair on the Union River, Courtney Creek, and Airport Creek. Woody debris levels in Everson Creek and stream 15.0513 were rated poor.

Table 10. Union River Watershed LWD Abundance.

Stream Name	Stream No.	Survey Length (meters)	LWD Total Pieces/ Channel Width (% conifer)	LWD Key Pieces (>0.50 meters) per Channel Width
Union River	15.0503	14,500	1.96 (34.2)	0.39
Courtney Creek	15.0505	4,500	1.3 (71.3)	0.3
Everson Creek	15.0507	1,500	0.7 (70.7)	0.1
Airport Creek	15.0512	4,500	1.3 (64.1)	0.2
Unnamed Stream	15.0513	500	0.3 (33.3)	0.1
Union Tributary 3	N/A	1,000	0.3 (13.4)	0.0

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. N/A = Not applicable.

Percent Pools

The HCSEG inventoried pool habitat in the Union River Watershed in the late 1990s. Pools comprised a mean 45.7% of stream surface area. Pool surface areas of tributaries are summarized in Table 11 (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Percent pools were rated fair to poor.

Table 11. Union River Watershed Pool Surface Area.

Stream Name	Stream No.	Survey Length (meters)	Mean Percent Pool Surface Area
Union River	15.0503	14,500	45.7
Courtney Creek	15.0505	4,500	14.3
Everson Creek	15.0507	1,500	10.8
Huson Creek	N/A	500	9.9
Bear Creek	15.0510	500	29.2
Airport Creek	15.0512	4,500	40.3
Unnamed Stream	15.0513	500	12.5
Union Tributary 3	N/A	1,000	1.9

Note: Raw data from (Hood Canal Salmon Enhancement Group 2003, Unpublished work). Calculations performed by author. Survey units with missing data were excluded from the calculations. N/A = Not applicable.

Pool Frequency

Pool frequency on the Union River mainstem was 5.9 channel widths per pool (Ames *et al.* 2000). Pool frequency was rated poor.

Pool Quality

May and Peterson (2002) rated pool quality good on the Union River, Courtney Creek, Bear Creek, Airport Creek, and Hazel Creek. This rating indicates that some deep pools with cover are present. Pool quality was rated good.

Streambank Stability

May and Peterson (2002) rated streambank stability fair (50 to 75% stable banks) on the lower mile of the Union River, good (75 to 90% stable banks) from RM 1.0 to RM 5.0, and optimal (>90% stable banks) upstream from RM 5.0. Courtney, Bear, and Hazel Creeks received optimal ratings, while Airport Creek received a good rating. Streambank stability was rated poor on the lower mile of the Union River, fair on the middle reach of the Union River and Airport Creek, and good on the upper Union River and Courtney, Bear, and Hazel Creeks.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Union River Watershed was 4.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

The majority of the watershed was completely logged by the 1930s (Amato 1996). Numerous farms, residences and associated bank armoring are present within the riparian zone of the Union River. Fifty-two percent of the riparian zone is forested. Deciduous trees compose 96% of the riparian forest. Sixty-two percent of the total riparian length is either sparsely vegetated or has a buffer less than 66 feet wide. Rural residential development, agriculture, and roads occupy 46% of the riparian zone (Ames *et al.* 2000). Riparian habitat ratings in May and Peterson (2002) indicate that riparian buffers on the Union River, Courtney Creek, Bear Creek, Airport Creek, and Hazel Creek are composed of a mix of mature and immature coniferous and deciduous trees. Buffers are narrow and fragmented on the lower five miles of the Union River and Airport Creek, and moderately wide with some development encroachment on the upper Union River and the other tributaries identified above. The mean riparian condition rating for the reaches with narrow buffers was 2.7, while the moderately wide buffers were rated 3.0. Riparian condition on the lower five miles of the Union River and Airport Creek was rated fair to poor. The upper Union River, Courtney Creek, Bear Creek, and Hazel Creek were rated fair.

Water Quality

Temperature

Summer water temperatures in the Union River are extremely cool, likely the result of releases from the Union River Reservoir (Hannafious 2003, Personal communication).

Dissolved Oxygen

No information was available.

Hydrology

Flow data from 1998 showed that outflow from the Union River Reservoir exceeded inflow during the summer chum spawning period (mid-August to mid-October) 43 of 59 days (73% of the time). Out of basin diversion may reduce flow during summer chum migration and spawning relative to historic conditions, reduce the amount of available spawning habitat and access, and impede access to upper stream reaches and tributaries (Ames *et al.* 2000). The Bremerton Water Utility maintains a gaging station below the dam. The gage has been operational since 1958, but no summary of flow data was available (Puget Sound Cooperative River Basin Team 1991). Administrative low flows are 3 cfs below McKenna Falls and 10 cfs at the river mouth (Ames *et al.* 2000). As of January 1963, 67 valid surface water claims had been filed in the Union River Watershed. Total flow claimed was 45.61 cfs, 41.025 cfs of which was allocated for public and domestic water supply systems. The City of Bremerton controlled 40.00 cfs of that amount. Water used for irrigation represented 2.215 cfs of the total surface water allocated. A water wheel used 1.02 cfs in nonconsumptive use. The remainder was used for fish propagation and other uses. No ground water claims were on record at that time. The Union River Reservoir has a total storage capacity of about 4,000 acre-feet at full pool (Garling and Molenaar 1965). Surveys conducted by the WDF in the late 1980s estimated summer flows of 6.2 cfs on Courtney Creek and 1.4 cfs on Bear Creek. Courtney Creek goes dry above RM 2.43 during low flow periods. Springs at RM 1.5 provide the majority of flow to Bear Creek. The stream goes dry above RM 1.85 during low flow periods (Baranski 1989, Unpublished work). No information was available to assess hydrologic maturity or percent impervious surfaces.

Biological Processes

Nutrients
No information was available to assess nutrient levels.

Biological Diversity
The Union River is the only stream in west WRIA 15 and north WRIA 14 to support a healthy run of summer chum salmon (Washington Department of Fish and Wildlife 2003). Biological diversity was rated good.

Lynch Cove Tributaries Watershed

Description
Sweetwater Creek (15.0524) enters Lynch Cove about 0.6 of a mile south of the mouth of the Union River. Alder Creek (15.0523) enters the Canal about 0.9 of a mile south of the Union River. Unnamed stream (15.0522) enters Hood Canal about 1.0 mile south of the mouth of the Union River.

Habitat Ratings

Access and Passage

Artificial Barriers
Fish passage barriers are present on two unnamed streams northeast of Sweetwater Creek. A culvert at the intersection of State Route 3 and Old Navy Yard Road is a complete barrier. A partial barrier is present next to the Clifton Deli. Portions of both of these streams are routed through underground channels (Ereth 2003, Personal communication). A waterwheel just upstream from State Route 3 is a complete barrier on Sweetwater Creek (Boad 2003, Personal communication). A culvert on Alder Creek is a partial barrier. No barriers are known to be present on stream 15.0522 (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated poor to fair.

Floodplains

No information was available to assess floodplain conditions.

Channel Conditions

No information was available to assess channel conditions.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Lynch Cove Unnamed Tributaries Watershed was 3.6 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

No riparian information was available.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

NORTH WRIA 14 SUBBASIN HABITAT LIMITING FACTORS

Subbasin Description

North WRIA 14 includes all WRIA 14 streams draining north into Hood Canal. See Map 7. The majority of streams are only 0.5 to 2.0 miles in length (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). The south shore of Hood Canal has been highly modified by State Route 106 and extensive residential development. The majority of the marine shoreline has been armored with bulkheads constructed of concrete, riprap, and wood (Washington Department of Ecology 2000b). Streamflows in these watersheds typically range from two to four cfs throughout the year (Boad 2003, Personal communication). Descriptions of individual watersheds are located in the habitat description of each stream.

Devereaux Creek (14.0124) Watershed

Description

Devereaux Creek enters Hood Canal about 1.5 miles southwest of the mouth of the Union River. The stream originates at Devereaux Lake just west of State Route 3. The mainstem is about three miles in length. However, a railroad crossing blocks anadromy at RM 1.0 (Hannafious 2003, Personal communication). Gradient in this watershed ranges from two to five percent (Boad 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

Two private drive road crossings are partial barriers to anadromous fish (Boad 2003, Personal communication), and a culvert just upstream from State Route 106 is a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Fill under a railroad grade at RM 1.0 has disrupted the surface connection of the stream, creating a complete barrier (Hannafious 2003, Personal communication). See Map 26. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

The lower portion of Devereaux Creek flows through a dense riparian forest before entering a salt marsh-mudflat complex. Natural floodplain function appears to be maintained (Washington Department of Ecology 2000b). Floodplain connectivity was rated good.

Loss of Floodplain Habitat

Downstream from the State Route 106 road crossing, a dense riparian forest, salt marsh, and mudflat provide ample floodplain habitat (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated good.

Channel Conditions

No information was available to assess fine sediment levels, pool frequency, pool quality, or streambank stability.

Large Woody Debris

Large woody debris abundance is less than 0.2 pieces per meter of channel length (Boad 2003, Personal communication). Large woody debris was rated poor.

Percent Pools

Pools comprise 20 to 40% of stream surface area (Boad 2003, Personal communication). Percent pools were rated poor to fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Devereaux Creek Watershed was 5.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

The riparian buffer is composed of a mixed stand of coniferous and deciduous trees roughly 15 to 20 years of age (Boad 2003, Personal communication). Riparian condition was rated fair.

Water Quality

No temperature or dissolved oxygen data were available.

Hydrology

No hydrology information was available.

Biological Processes

Nutrients

Culverts and a railroad fill block anadromous fish access to the majority of this watershed. Nutrients were rated poor.

Biological Diversity
Anadromous salmonids are unable to reach the majority of this watershed because of fish passage barriers. Anadromous fish are assumed to have been present throughout the watershed prior to the elimination of access. Biological diversity was rated poor.

Springbrook (Lakewood) Creek (14.0126) Watershed

Description
Springbrook Creek enters Hood Canal at Sunset Beach. The stream is about 1.6 miles long with an equal length of tributaries (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Gradient in this watershed ranges from four to six percent (Boad 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers
A culvert on the first right bank tributary of Springbrook Creek is a complete barrier to anadromous salmonids (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). However, a steep gradient and large cobble substrate limit the salmonid production capacity of this stream (Boad 2003, Personal communication). See Map 26. Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity
The State Route 106 road crossing and residential development have eliminated floodplain connectivity downstream from the highway (Washington Department of Ecology 2000b). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat
Floodplain habitat downstream from SR 106 was lost to filling and residential development (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor.

Channel Conditions
No information was available to assess fine sediment levels, pool frequency, pool quality, or streambank stability.

Large Woody Debris
Large woody debris abundance ranges from 0.2 to 0.4 pieces per meter of channel length (Boad 2003, Personal communication). Large woody debris was rated poor to fair.

Percent Pools

Pools comprise less than 20 percent of stream surface area (Boad 2003, Personal communication). Percent pools were rated poor.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Springbrook Creek Watershed was 3.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

The riparian buffer is composed of a contiguous mixed stand of mature second growth coniferous and deciduous trees. Steep side slopes in the watershed limit residential development within the riparian zone (Boad 2003, Personal communication). Riparian condition was rated good.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

Holyoke Creek (14.0127) Watershed

Description

Holyoke Creek enters Hood Canal about 0.5 of a mile west of Springbrook Creek. The stream is about 2.4 miles long with about two miles of tributaries (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Some single family homes are present along the lower 0.2 miles of stream, but the remainder of the watershed is forested (Ereth 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in the Holyoke Creek Watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

The State Route 106 road crossing and residential development have eliminated floodplain connectivity downstream from the highway (Washington Department of Ecology 2000b). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Floodplain habitat downstream from SR 106 was lost to filling and residential development (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor.

Channel Conditions

No information was available to assess fine sediment levels, pool frequency, pool quality, or streambank stability.

Large Woody Debris

Large woody debris abundance ranges from 0.4 to 0.6 pieces per meter of channel length (Boad 2003, Personal communication). Large woody debris was rated good.

Percent Pools

Pools comprise about 30 to 50% of stream surface area (Boad 2003, Personal communication). Percent pools were rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Holyoke Creek Watershed was 4.8 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

The riparian buffer is comprised of a contiguous mixed stand of mature coniferous and deciduous trees (Boad 2003, Personal communication). Riparian condition was rated good.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

Happy Hollow Creek (14.0129) Watershed

Description

Happy Hollow Creek (stream 14.0129) enters Hood Canal about 1.9 miles west of Holyoke Creek. The stream is about 0.8 of a mile long (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Gradient in this watershed ranges from two to four percent (Boad 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

The State Route 106 crossing has severely constrained the mouth of Happy Hollow Creek. This constriction has altered sediment and LWD transport into Hood Canal, as well as tidal influence upstream from the road crossing (Boad 2003, Personal communication). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Most streams draining to Hood Canal deposit alluvial fans at their mouths. The State Route 106 road crossing of Happy Hollow Creek prevents the stream from meandering across an alluvial fan (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor.

Channel Conditions

No information was available to assess fine sediment levels, pool frequency, pool quality, or streambank stability.

Large Woody Debris

Large woody debris abundance ranges from 0.3 to 0.5 pieces per meter of channel length (Boad 2003, Personal communication). Large woody debris was rated fair to good.

Percent Pools

Pools comprise 20 to 50% of stream surface area (Boad 2003, Personal communication). Percent pools were rated fair.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Stream 14.0129 Watershed was 0.7 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated good.

Riparian Zones

Riparian Condition

The riparian zone is comprised of a mixed forest of mature second growth coniferous and deciduous trees. Riparian condition was rated good.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No hydrology information was available.

Unnamed Stream (14.0130) Watershed

Description

Unnamed Stream 14.0130 enters Hood Canal about 0.5 of a mile west of Stream 14.0129. The stream is about 1.5 miles in length with about 0.4 of a mile of tributaries (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003).

Habitat Ratings

Access and Passage

Artificial Barriers

No man-made barriers are known to be present in this watershed (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity

Residential development downstream from State Route 106 has severely constrained the channel, eliminating access to the floodplain (Washington Department of Ecology 2000b). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

Residential development downstream from State Route 106 has completely eliminated floodplain habitat (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor.

Channel Conditions

No information was available to assess channel conditions.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Stream 14.0130 Watershed was 2.9 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated fair.

Riparian Zones

Riparian Condition

No information was available to assess riparian condition.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No information was available to assess biological processes.

Twanoh Falls Creek (14.0132) Watershed

Description

Twanoh Falls Creek enters Hood Canal at Forest Beach. The stream is about 1.7 miles in length with about 1.6 miles of tributaries (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Potential anadromous fish habitat extends from the mouth to RM 1.24 were a natural falls blocks fish passage. Gradient in this watershed ranges from three to five percent (Boad 2003, Personal communication). Dense residential development is present along both sides of the lower half-mile of stream (Ereth 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at the State Route 106 crossing is a velocity barrier during high flows. A culvert upstream at RM 0.25 is a partial barrier to anadromous fish (Boad 2003, Personal communication, Ereth 2003, Personal communication). This structure is identified as a complete barrier on Map 26 (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Artificial barriers were rated poor.

Floodplains

Floodplain Connectivity

The lower 100 meters of stream has been channelized and armored with riprap (Washington Department of Ecology 2000b, Boad 2003, Personal communication). Channel constriction on the lower 100 meters of stream prevents lateral channel movement and reduces sediment transport capacity (Ereth 2003, Personal communication). Floodplain connectivity was rated poor.

Loss of Floodplain Habitat

The floodplain along the lower 100 meters of stream has been filled to create a private community park (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor.

Channel Conditions

No information was available to assess fine sediment levels, pool frequency, or pool quality.

Large Woody Debris

Upstream from State Route 106, large woody debris abundance ranges from 0.4 to 0.6 pieces per meter of channel length. Woody debris abundance is low in the lower 100 meter channelized reach (Boad 2003, Personal communication). Large woody debris was rated good upstream from SR 106 and poor downstream from the highway.

Percent Pools

Pools comprise 30 to 50% of stream surface area (Boad 2003, Personal communication). Percent pools were rated fair.

Streambank Stability

Banks along the lower 100 meters of stream are armored with riprap (Washington Department of Ecology 2000b, Boad 2003, Personal communication). Streambank stability was rated poor on the lower 100 meter reach. No information was available to assess conditions upstream.

Sediment Input

The lower 100 meters of constricted channel reduce the sediment transport capacity of Twanoh Falls Creek. Sediment builds up at the culvert outfall, necessitating nearly annual dredging to maintain channel capacity (Ereth 2003, Personal communication). No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Twanoh Falls Creek Watershed was 5.4 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Upstream from SR 106, the riparian buffer is composed of a mix of mature coniferous and deciduous trees (Boad 2003, Personal communication). Downstream from SR 106, the majority of native riparian vegetation has been replaced with lawns and riprap (Washington Department of Ecology 2000b, Boad 2003, Personal communication). Riparian condition was rated good upstream from SR 106 and poor downstream along the channelized reach.

Water Quality

No water quality information was available.

Hydrology
No hydrology information was available.

Biological Processes
No biological processes information was available.

Twanoh Creek (14.0134) Watershed

Description
Twanoh Creek enters Hood Canal at Twanoh State Park. The stream is about 1.5 miles in length with about 0.9 of a mile of tributaries. Unnamed stream 14.0135 enters the left bank of Twanoh Creek at RM 0.65. The stream is about 0.6 of a mile in length (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Large numbers of spawning fall chum salmon provide a unique opportunity to educate park visitors about the Pacific salmon life cycle (Boad 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers
No man-made barriers are known to be present on Twanoh Creek (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated good.

Floodplains

Floodplain Connectivity
Below State Route 106, the channel is armored with riprap (Kuttel 2002). A fluvial salt marsh was historically present at the current site of the east parking lot and lawn at Twanoh State Park (Point No Point Treaty Council 2003, Unpublished work). The stream channel is no longer able to migrate across an alluvial fan. Floodplain connectivity was rated poor.

Loss of Floodplain Habitat
Above State Route 106, gradient is fairly steep, naturally limiting floodplain habitat. Below the highway, gradient is relatively flat. Historically floodplain habitat may have been present, but the stream has been channelized and banks armored with riprap. No off-channel habitat was observed (Kuttel 2002). Loss of floodplain habitat was rated poor.

Channel Conditions

Fine Sediment

During a site visit in December 2002, gravel was the dominant substrate observed from the mouth upstream about 0.25 miles. Substrate embeddedness appeared to be very low, likely the result of extensive chum salmon spawning activity prior to the visit. Embeddedness appeared to increase upstream from the chum salmon spawning reach (Kuttel 2002). Fine sediment was rated good in the lower reach. No information was available to evaluate conditions upstream.

Large Woody Debris

During a site visit in December 2002, some small woody debris was observed in the channel, although it was not common. Some large coniferous logs were present on the left bank hillslope and could be a source of future LWD (Kuttel 2002). Large woody debris abundance is less than 0.2 pieces per meter of channel length (Boad 2003, Personal communication). Large woody debris is relatively abundant in the upper reaches of Twanoh Creek (Ereth 2003, Personal communication). Large woody debris was rated poor to fair.

Percent Pools

Pools comprise less than 20% of stream surface area (Boad 2003, Personal communication). Percent pools were rated poor.

Pool Frequency

No pools were observed in December 2002 from the mouth upstream about 0.25 miles. The channel was dominated by riffles and glides, likely the result of the relatively steep gradient and low LWD abundance (Kuttel 2002). Pool frequency was rated poor.

Pool Quality

Steep gradient and low woody debris abundance limit pool formation. No pools were observed in December 2002 from the mouth upstream about 0.25 mile (Kuttel 2002). Pool quality was rated poor.

Streambank Stability

Downstream from State Route 106, banks have been armored with riprap (Kuttel 2002). The mouth of the creek is heavily armored (Washington Department of Ecology 2000b). See oblique photo #151812. Upstream from SR 106, bank stability appeared to be maintained by a dense growth of deciduous shrubs (Kuttel 2002). Bank stability was rated poor on the lower armored reach, and good upstream from SR 106.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Twanoh Creek Watershed was 4.1 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

Mature conifers dominate the riparian overstory downstream from State Route 106. This stream reach is a popular area to view spawning chum salmon. A fence has been erected along both sides of the stream to prevent access to the creek. With the exception of grass and a few young alders in the creek channel just above the mouth, little vegetation is present in the understory (Kuttel 2002). Upstream from State Route 106, a trail closely parallels the left bank of the stream. Mature bigleaf maple and red alder are the dominant overstory vegetation. Oldgrowth western redcedar are scattered throughout the riparian zone. A narrow, but generally dense, buffer of salmonberry, elderberry, ninebark, and other deciduous shrubs is present on the left bank. Grass is the dominant understory vegetation adjacent to the State Park campground. Upstream from the campsite, native deciduous shrub vegetation is well established (Kuttel 2002). Riparian condition was rated fair.

Water Quality

No information was available.

Hydrology

No information was available.

Biological Processes

Nutrients

Hundreds of chum salmon carcasses were observed from the mouth to about RM 0.25 in mid-December 2002 (Kuttel 2002). Nutrients were rated good.

Biological Diversity

No information was available.

Nordstrom and Alderbrook Creek (unnumbered) Watersheds

Description

Nordstrom Creek enters Hood Canal about 2.0 miles east of the town of Union. The mainstem is about 0.8 miles in length with about 0.5 miles of tributary streams. Alderbrook Creek enters Hood Canal about 0.3 miles west of Nordstrom Creek. The stream is about 0.7 miles in length (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Gradient in the Nordstrom Creek Watershed ranges from two to four percent. Alderbrook Creek is steeper with a gradient ranging from five to eight percent (Boad 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at State Route 106, and a weir and channelized reach downstream of the highway are complete barriers to anadromous fish access in Nordstrom Creek (Boad 2003, Personal communication, Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Culverts at RM 0.1 (SR 106 crossing) and RM 0.2 (golf course access road) of Alderbrook Creek are complete barriers to anadromous fish passage (Ereth 2003, Personal communication). See Map 26. Artificial barriers were rated poor for both watersheds. Although anadromous fish do not have access to Nordstrom Creek, a resident coastal cutthroat trout population is present (Boad 2003, Personal communication).

Floodplains

Floodplain Connectivity

The lower reach of Nordstrom Creek flows through an underground channel, eliminating connectivity with the floodplain (Boad 2003, Personal communication). Floodplain connectivity on the lower reach of Alderbrook Creek is limited by facilities at the Alderbrook Inn (Washington Department of Ecology 2000b). Floodplain connectivity was rated poor for both watersheds.

Loss of Floodplain Habitat

Floodplain habitat along the lower reach of Nordstrom Creek has been lost to channelization, filling, and residential development. Filling and development at the Alderbrook Inn have caused a loss of floodplain habitat on lower Alderbrook Creek (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor for both watersheds.

Channel Conditions

No information was available to assess fine sediment levels, pool frequency, pool quality, or streambank stability.

Large Woody Debris

Large woody debris abundance in Nordstrom Creek ranges from 0.2 to 0.4 pieces per meter of channel length. Woody debris abundance in Alderbrook Creek ranges from 0.3 to 0.5 pieces per meter of channel length (Boad 2003, Personal communication). Large woody debris was rated fair in Nordstrom Creek and fair to good in Alderbrook Creek.

Percent Pools

Pools comprise about 20 to 50% of stream surface area in Nordstrom Creek. Alderbrook Creek has a steeper gradient, resulting in less than 20% pool surface area (Boad 2003, Personal communication). Percent pools were rated fair for Nordstrom Creek and poor for Alderbrook Creek.

<u>Sediment Input</u>

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Nordstrom-Alderbrook Creeks Watershed was 10.3 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

<u>Riparian Zones</u>

Riparian Condition

No information was available to assess riparian condition on Nordstrom Creek. Riparian vegetation along Alderbrook Creek below SR 106 was removed for construction of the Alderbrook Inn facilities. In the future, SR 106 at the Alderbrook Inn may be moved inland about 200 feet. If this takes place, the property owner would like to restore the natural channel geometry of Alderbrook Creek downstream from the highway. Mature second growth trees with some old growth coniferous trees are the dominant riparian vegetation along Alderbrook Creek upstream from SR 106 (Boad 2003, Personal communication). Riparian condition was rated good on Alderbrook Creek upstream from SR 106 and poor downstream from the highway.

<u>Water Quality</u>

No water quality information was available.

<u>Hydrology</u>

No hydrology information was available.

<u>Biological Processes</u>

Nutrients

Fish passage barriers on lower Nordstrom Creek prevent anadromous fish access to Nordstrom Creek. Anadromous fish are presumed to have been present prior to human development along the lower reach. Two complete barriers on the lower 0.2 miles of Alderbrook Creek prevent anadromous fish access to a large portion of the watershed.

Lack of anadromous fish escapement in both watersheds is presumed to cause a shortage of marine-derived nutrients. Nutrients were rated poor for both watersheds.

Biological Diversity

Fish passage barriers in the lower reaches of both streams prevent anadromous fish access to the majority of both watersheds. Anadromous fish are presumed to have been present prior to human development that created the passage barriers. Biological diversity was rated poor for both watersheds because of the lack of anadromous fish escapement.

Dalby (14.0139) and Big Bend Creek (14.0138) Watersheds

Description

Dalby Creek enters Hood Canal about 1.5 miles east of the town of Union. Although the maps included with this report show Dalby Creek as a tributary of Big Bend Creek, the stream actually flows directly to the Canal (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Gradient in the Dalby Creek Watershed ranges from five to eight percent, steeper than most other streams in north WRIA 14 (Boad 2003, Personal communication). Big Bend Creek enters the Canal immediately to the west of Dalby Creek. Both streams are about one mile long (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Big Bend Creek is one of the largest streams in north WRIA 14 (Ereth 2003, Personal communication).

Habitat Ratings

Access and Passage

Artificial Barriers

A culvert at the State Route 106 crossing of Dalby Creek is a partial barrier to anadromous fish. This culvert will be replaced with a bridge if a proposed highway relocation project is implemented (Ereth 2003, Personal communication). A waterwheel on lower Dalby Creek also inhibits fish passage (Boad 2003, Personal communication). An uncharacterized structure at RM 0.7 on Big Bend Creek is a complete barrier to anadromous fish (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). See Map 26. Artificial barriers were rated poor on Dalby Creek and fair on Big Bend Creek.

Floodplains

Floodplain Connectivity

Residential development downstream from SR 106 limits floodplain connectivity on the lower portion of both streams (Washington Department of Ecology 2000b). Floodplain connectivity was rated poor for both watersheds.

Loss of Floodplain Habitat

Floodplain habitat on both streams has been lost to filling, residential development, and State Route 106 (Washington Department of Ecology 2000b). Loss of floodplain habitat was rated poor for both streams.

Channel Conditions

No information was available to assess fine sediment levels, pool frequency, pool quality, or streambank stability.

Large Woody Debris

Large woody debris abundance in Dalby Creek ranges from 0.3 to 0.5 pieces per meter of channel length (Boad 2003, Personal communication). No woody debris information was available for Big Bend Creek. Large woody debris was rated fair to good on Dalby Creek.

Percent Pools

Dalby Creek has a steep gradient, limiting pool habitat to less than 20% of stream surface area (Boad 2003, Personal communication). No information was available for Big Bend Creek. Percent pools were rated poor on Dalby Creek.

Sediment Input

No information was available to assess sediment supply or mass wasting.

Road Density

Road density in the Big Bend-Dalby Creek Watershed was 6.1 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). Road density was rated poor.

Riparian Zones

Riparian Condition

The riparian buffer along Dalby Creek is dominated by mature coniferous trees (Boad 2003, Personal communication, Ereth 2003, Personal communication). A mixed forest of mature coniferous and deciduous trees dominates the riparian zone on Big Bend Creek (Ereth 2003, Personal communication). Riparian condition was rated good on Dalby Creek and fair on Big Bend Creek.

Water Quality

No water quality information was available.

Hydrology

No hydrology information was available.

Biological Processes

No biological processes information was available.

SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington State Conservation Commission (WCC) is charged with identifying habitat factors limiting production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 12) were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to divide habitat condition ratings into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed by WCC, with the expectation that it will be modified or replaced as better data become available.

Table 12. Salmonid Habitat Rating Criteria Source Documents.

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
TAG 2003	The assessment of conditions is based on the professional knowledge and judgment of the Technical Advisory Group.	RCW 77 West WRIA 15/North WRIA 14 Habitat Limiting Factors Technical Advisory Group (See Acknowledgements)
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

The ratings adopted by the WCC are presented in Table 14. These ratings are intended to be used as a coarse screen to identify the most significant habitat limiting factors in a WRIA, not as thresholds for regulatory purposes. They will provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, where data are unavailable or where analysis of data has not been conducted, the professional expertise of the TAG is used. In some cases, there may be local conditions that warrant deviation from the rating standards presented here. Additional rating standards will be included as they become available and will supersede the standards used in this report.

Table 13. WCC Salmonid Habitat Condition Rating Criteria for West WRIA 15 and North WRIA 14.

Habitat Factor	**Parameter/Unit**	**Channel Type**	**Poor**	**Fair**	**Good**	**Source** [1.]
<u>Access and Passage</u>						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
<u>Floodplains</u>						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
<u>Channel Conditions</u>						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/ NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source [1.]
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m) / Diameter (m) / Length (m) 0-5 / 0.4 / 8 6-10 / 0.55 / 10 11-15 / 0.65 / 18 16-20 / 0.7 / 24				
Percent Pools	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	channel widths per pool	>15 m	N/A	N/A	chann width / pools/mile / cw/pool 50' / 26 / 4.1 75' / 23 / 3.1 100' / 18 / 2.9	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source [1.]
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/ WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	N/A	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	N/A	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source [1.]
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	• 75'-150' or 50-100% of site potential tree height (whichever is greater) AND • Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source [1.]
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	N/A	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
Flow	% Impervious Surfaces	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC
Biological Diversity	Exotic species presence/absence and/or native species populations depressed or extirpated	All	Exotic plants and/or animals out-compete native plants/animals and/or native species have been extirpated	Exotic plants and/or animals are present, but do not presently out-compete native plants/animals and/or native species populations are depressed	No exotic plants and/or animals are present and native species populations are healthy	WCC TAG
Note: 1. See Table 12 for source citations. N/A = not applicable						

SALMONID HABITAT ASSESSMENT BY WATERSHED

The narrative descriptions of riverine habitat conditions were compared to the rating criteria found in Table 13 to assess salmonid habitat conditions across the West Kitsap Basin and North Kennedy-Goldsborough Basin. Each watershed discussed in the report has a corresponding assessment in Table 14.

Table 14. Salmonid Habitat Assessment by Watershed.

Legend	Access & Passage	Floodplains		Channel Conditions						Sediment Input			Riparian Zones	Water Quality		Hydrology		Biological Processes	
Stream Name	*Artificial Barriers*	*Connectivity*	*Lost Habitat*	*Fine Sediment*	*LWD*	*Percent Pools*	*Pool Frequency*	*Pool Quality*	*Bank Stability*	*Sediment Supply*	*Mass Wasting*	*Road Density*	*Riparian Condition*	*Temperature*	*Dissolved Oxygen*	*Hydrologic Maturity*	*Impervious Surfaces*	*Nutrients*	*Biological Diversity*
Port Gamble Subbasin																			
Hawks Hole Cr.	G2-F1	F1	P2-G2	F1-P1	P1	P1	DG	F1	P1	DG	DG	P1	F1	DG	DG	DG	DG	DG	DG
15.0348-.0349	P2	G2	G1	F1-P1	P1	P1	DG	F1	F1	DG	DG	P1	F1	DG	DG	P2	DG	DG	DG
Little Boston Cr.	P2	F1	P2	F1-P1	P1	P1	DG	F1	F1	DG	DG	P1	F1	G1	DG	DG	DG	DG	DG
Middle Cr.	P2	F1-G1	G1	F1-P1	P1	P1	DG	F1	F1	DG	DG	F1	F1	G1	DG	DG	DG	DG	DG
Martha John Cr.	F1	G1,2	G1	G1-F1 F1	P1	F1	DG	G1	F1-G1	DG	DG	F1	F1-P1 G1-F1	G1-P1	DG	DG	DG	DG	DG
Gamble Cr.	G2-DG	F1-G1	F1-G1	G1-P1	G1	G1-P1	P1	F1-G1	P1-F1	P2	DG	P1	P1-G1	P1-G1	DG	DG	DG	DG	DG
Todhunter Cr.	P2	F1	F1	G1-F1	P1	P1	DG	F1	F1	DG	DG	F1	F1-P1	DG	DG	DG	DG	DG	DG
L. DeCouteau Cr.	P2	F1	F1	G1-F1	P1	P1	DG	F1	F1	DG	DG	F1	F1-P1	DG	DG	SP2	DG	DG	DG
Machias Cr.	F2	NA	NA	DG	DG	DG	DG	DG	DG	DG	DG	G1	DG	DG	DG	DG	DG	DG	DG
Spring Cr.	P2	F1	F1	G1-F1	P1	P1	DG	F1	F1	DG	DG	P1	F1	G1	DG	DG	DG	DG	DG
Cougar & Kinman Cr.	F2-P2	F1 F1-G1	F1,2	F1-G1 F1-P1	P1	F1-P1	P1	F1	F1-P1	DG	DG	P1	F1 F1-P1	G1-F1	DG	DG	DG	DG	DG
Jump Off Joe Cr.	P2	P2	P2	F1-G1	P1,2	P1,2	DG	F1	P1	DG	DG	F1	F1-P1	DG	DG	DG	DG	DG	DG

Legend	Access & Passage	Floodplains		Channel Conditions						Sediment Input			Riparian Zones	Water Quality		Hydrology		Biological Processes	
Stream Name	*Artificial Barriers*	*Connectivity*	*Lost Habitat*	*Fine Sediment*	*LWD*	*Percent Pools*	*Pool Frequency*	*Pool Quality*	*Bank Stability*	*Sediment Supply*	*Mass Wasting*	*Road Density*	*Riparian Condition*	*Temperature*	*Dissolved Oxygen*	*Hydrologic Maturity*	*Impervious Surfaces*	*Nutrients*	*Biological Diversity*
Port Gamble Subbasin Cont'd																			
Cattail Cr.	P1	F1	F1	F1-G1	P1	P1	DG	F1	F1	DG	G1	G1	G1	DG	DG	DG	DG	P1	P1
Devils Hole Cr.	P1	F1	F1	F1-G1	P1	F1	DG	F1	F1	DG	G1	G1-P1	G1-F1	DG	DG	DG	DG	DG	DG
15.0376	G1	F1	F1	F1-G1	P1	P1	DG	F1	F1	DG	DG	F1	F1-P1	DG	DG	DG	DG	DG	DG
Big Beef-Anderson Subbasin																			
Little Anderson Cr.	F1	F1-G1	G1	F1-G1	P1-F1	P1	P1	F1-P1	P1-G1	P2	G1	P1	F1-P1 F1	G1	DG	P1	F1	DG	DG
Johnson Cr.	P1	F1	F1	F1-G1	P1	P1	DG	F1	P1	DG	G1	P1	F1-P1	DG	DG	DG	F1	DG	DG
Big Beef Cr.	F1	F1	F1	F1-G1	P1-F1	G1	F1	G1	G1	P1	G1	P1	F1	F1-P1	DG	G1	F1	DG	DG
Little Beef Cr.	G1	F1-G1	G1	F1-G1	F1	F1	DG	G1	G1	DG	G1	P1	G1-F1	DG	DG	P1	F1	DG	DG
Seabeck Cr.	F1	P1	P1	P1	P1-F1	P1-F1	P1-F1	G1	F1	P1	G1	P1	F1-P1	G1	DG	P1	F1	DG	DG
15.0403	P1	G1	G1	G1	F1	P1	DG	G1	G1	DG	G1	P1	G1	DG	DG	DG	DG	DG	DG
Stavis Cr.	F1	G1	G1	F1-G1	F1	G1	P1-DG	G1	F1-P1	P1	P1	P1	G1	F1-G1	DG	G1	G1	DG	DG
Boyce Cr.	G1	F1-G1	G1	F1-G1	P1-F1	F1-G1	DG	G1	G1	DG	G1	P1	F1	DG	DG	G1	DG	DG	DG
Harding Cr.	P1- DG	F1-G1	G1	F1-G1	P1-F1	P1-F1	DG	G1	G1	SP2	P1	P1	F1	G1	DG	G1	DG	DG	DG

Legend	Access & Passage	Floodplains		Channel Conditions						Sediment Input			Riparian Zones	Water Quality		Hydrology		Biological Processes	
Stream Name	*Artificial Barriers*	*Connectivity*	*Lost Habitat*	*Fine Sediment*	*LWD*	*Percent Pools*	*Pool Frequency*	*Pool Quality*	*Bank Stability*	*Sediment Supply*	*Mass Wasting*	*Road Density*	*Riparian Condition*	*Temperature*	*Dissolved Oxygen*	*Hydrologic Maturity*	*Impervious Surfaces*	*Nutrients*	*Biological Diversity*
Big Beef-Anderson Subbasin Cont'd																			
Anderson Cr.	F1	P1	F1-G1	F1-G1	F1-P1	G1-P1	G1-P1	G1-F1	G1-F1	SP2	P1	P1	P1	G1	DG	G1	F1	DG	DG
Thomas Cr.	P1	F1-G1	G1	F1-G1	P1	P1	DG	F1	F1	SP2	P1	P1	F1-P1	DG	DG	P1	DG	DG	DG
Tahuya-Dewatto Subbasin																			
15.0418	G1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	G1	DG	DG	DG	DG	DG	DG	DG
Dewatto R.	G1	G1-F1	G1	G1-P1	G1-F1	G1-F1	P1-F1	G1	G1	DG	DG	P1	F1	F1- P1	DG	DG	DG	DG	DG
Little Dewatto Cr.	G1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	P1	DG	DG	DG	DG	DG	DG	DG
Rendsland Cr.	G1	G1-F1	G1	F1-G1	F1	F1	DG	G1	G1	DG	DG	P1	F1-G1	DG	DG	DG	DG	DG	DG
Browns Cr.	P1	G1-F1	G1	F1-G1	F1	F1-P1	DG	G1	F1	DG	DG	P1	F1	DG	DG	DG	DG	DG	DG
Caldervin Cr.	G1	G1-F1	G1	F1-G1	F1	F1	DG	G1	G1	DG	G2	P1	F1-G1	G2	DG	DG	DG	DG	DG
Lower Tahuya R.	F1	F1	F1	G1-F1	G1-P1	G1-P1	F1	G1	F1- P1	DG	DG	P1	F1	F1	DG	DG	DG	DG	DG
Middle Tahuya R.	F1	G1	G1	G1-F1	G1-P1	G1	F1	G1	G1	DG	DG	P1	F1	F1- G1	DG	DG	DG	DG	DG
Upper Tahuya R.	G1	G1	G1	G1	F1	G1	DG	G1	G1	DG	DG	P1	F1	P1	DG	DG	DG	DG	DG

Legend	Access & Passage	Floodplains		Channel Conditions						Sediment Input			Riparian Zones	Water Quality		Hydrology		Biological Processes	
Stream Name	*Artificial Barriers*	*Connectivity*	*Lost Habitat*	*Fine Sediment*	*LWD*	*Percent Pools*	*Pool Frequency*	*Pool Quality*	*Bank Stability*	*Sediment Supply*	*Mass Wasting*	*Road Density*	*Riparian Condition*	*Temperature*	*Dissolved Oxygen*	*Hydrologic Maturity*	*Impervious Surfaces*	*Nutrients*	*Biological Diversity*
Union-Mission Subbasin																			
Shoofly Cr.	G1	P1	P1	F1-G1	F1	P1	DG	G1	F1	DG	DG	P1	F1	DG	DG	DG	DG	DG	DG
Little Shoofly Cr.	G1	P1	P1	F1-G1	F1	P1	DG	G1	F1	DG	DG	P1	F1	DG	DG	DG	DG	DG	DG
Cady Cr.	G1	F1-G1	G1	F1-G1	F1	P1	DG	G1	F1	DG	DG	G1	F1	DG	DG	DG	DG	DG	DG
Northshore Nursery Cr.	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	P1	DG	DG	DG	DG	DG	DG	DG
Stimson Cr.	F2	F1	F1	F1-G1	F1	P1	DG	G1	F1	DG	DG	P1	F1	DG	DG	DG	DG	DG	DG
Sundstrom Cr.	G1	F1-G1	G1	F1-G1	F1	P1	DG	G1	F1	DG	DG	P1	F1	DG	DG	DG	DG	DG	DG
Little Mission Cr.	P1	F1-G1	G1	G1	F1	F1	DG	G1	G1	DG	DG	F1	G1-F1	DG	DG	DG	DG	DG	DG
Big Mission Cr.	F1	F1 F1-G1	F1-G1	G1	F1	F1-G1	P1	G1	G1-P1	DG	DG	P1	F1-P1 F1	DG	DG	DG	DG	DG	DG
Union R.	F1	F1 F1-G1	F1-G1	F1-G1	F1-P1	F1-P1	P1	G1	P1-G1	DG	DG	P1	F1-P1 F1	G2	DG	DG	DG	DG	G1
Lynch Cove Tributaries	P1-F1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	P1	DG	DG	DG	DG	DG	DG	DG
North WRIA 14 Subbasin																			
Devereaux Cr.	P1	G1	G1	DG	P2	P2-F2	DG	DG	DG	DG	DG	P1	F2	DG	DG	DG	DG	P2	P2
Springbrook Cr.	P1	P1	P1	DG	P2-F2	P2	DG	DG	DG	DG	DG	P1	G2	DG	DG	DG	DG	DG	DG

Legend	Access & Passage	Floodplains		Channel Conditions						Sediment Input			Riparian Zones	Water Quality		Hydrology		Biological Processes	
Stream Name	*Artificial Barriers*	*Connectivity*	*Lost Habitat*	*Fine Sediment*	*LWD*	*Percent Pools*	*Pool Frequency*	*Pool Quality*	*Bank Stability*	*Sediment Supply*	*Mass Wasting*	*Road Density*	*Riparian Condition*	*Temperature*	*Dissolved Oxygen*	*Hydrologic Maturity*	*Impervious Surfaces*	*Nutrients*	*Biological Diversity*
North WRIA 14 Subbasin Cont'd																			
Holyoke Cr.	G1	P1	P1	DG	G2	F2	DG	DG	DG	DG	DG	P1	G2	DG	DG	DG	DG	DG	DG
14.0129	G1	P1	P1	DG	F2-G2	F2	DG	DG	DG	DG	DG	G1	G2	DG	DG	DG	DG	DG	DG
14.0130	G1	P1	P1	DG	DG	DG	DG	DG	DG	DG	DG	F1	DG	DG	DG	DG	DG	DG	DG
Twanoh Falls Cr.	P1	P2	P2	DG	G2-P2	F2	DG	DG	P2-DG	DG	DG	P1	G2- P2	DG	DG	DG	DG	DG	DG
Twanoh Cr.	G1	P2	P2	G2-DG	P2-F2	P2	P2	P2	P2-G2	DG	DG	P1	F2	DG	DG	DG	DG	G2	DG
Nordstrom Cr	P1	P1	P1	DG	F2	F2	DG	DG	DG	DG	DG	P1	DG	DG	DG	DG	DG	P2	P2
Alderbrook Cr.*	P1	P1	P1	DG	F2-G2	P2	DG	DG	DG	DG	DG	P1	G2- P2	DG	DG	DG	DG	P2	P2
Dalby Cr*	P1	P1	P1	DG	F2-G2	P2	DG	DG	DG	DG	DG	P1	G2	DG	DG	DG	DG	DG	DG
Big Bend Cr*	F1	P1	P1	DG	DG	DG	DG	DG	DG	DG	DG	P1	F2	DG	DG	DG	DG	DG	DG

Legend	
P = Average habitat condition considered poor (Not Properly Functioning)	DG = Data Gap: habitat on the stream or reach has not been evaluated; TAG members had little or no knowledge of habitat conditions. The parameter was not rated.
F = Average habitat condition considered fair (At Risk)	NB = Natural Barrier
G = Average habitat condition considered good (Properly Functioning)	NAT = Natural Condition
1= Quantitative studies or published reports documenting habitat condition	N/A = Not Applicable
2 = Professional knowledge of the West WRIA 15/North WRIA 14 TAG members	N/E = Not Evaluated
S = Suspected	* Note: These streams are referred to by several names depending upon the source. See Table 34 for an explanation of where these streams are located.

HABITAT LIMITING FACTORS, POTENTIAL CAUSES, AND RECOMMENDATIONS

A habitat parameter was considered limiting if it was rated "poor" in Table 14. Habitat limiting factors for west WRIA 15 and north WRIA 14 are summarized in Table 15. This table also identifies probable causes for poor habitat conditions and makes recommendations to improve conditions.

Table 15. Riverine Habitat Limiting Factors, Potential Causes, and Recommendations.

Habitat Limiting Factor	**Watershed (Rated Poor in** Table 14**)** Note: Legend to watershed numbers is located at end of table	**Potential Human-Induced Causes**	**Recommendations**
Artificial Barriers	2-4, 7, 8, 10-14, 17, 21, 24, 26, 31, 39, 42, 45-47, 51, 53-55	Dams Failed culverts Grade control structures	Install fish passage structures Replace failed culverts Replace grade control structures
Floodplain Connectivity	12, 20, 25, 36, 37, 47-56	Floodplain development including homes, dikes, and roads Channelization Filling	Limit floodplain development and where possible reestablish connectivity Restore natural channel morphology Limit filling activities and where possible remove existing fill
Lost Floodplain Habitat	1, 3, 12, 20, 36, 37, 47-56	Floodplain development including homes, dikes, and roads Channelization Filling	Limit floodplain development and where possible reestablish connectivity Restore natural channel morphology and off-channel habitats Limit filling activities and where possible remove existing fill
Fine Sediment	1-4, 6, 11, 20, 28	Clearing of forest cover Unnaturally high runoff from impervious surfaces Erosion of banks, forest roads	Maintain natural forest cover Limit impervious surfaces area, reduce existing impervious surfaces area Maintain riparian vegetation along streams, properly maintain forest roads
Large Woody Debris	1-5, 7, 8, 10-18, 20, 23-26, 31, 33, 34, 44, 46, 47, 51, 52	Removal of wood from stream during "clean outs" Degraded riparian zone conditions	Leave large woody debris in streams Maintain mature riparian forest buffers, preferably composed of coniferous trees that provide large and long-lived large woody debris
Percent Pools	1-4, 6-8, 10-13, 15-17, 20, 21, 24-26, 31, 33, 36-38, 40, 41, 44, 46, 47, 52, 54, 55	Low large woody debris abundance because of "clean outs" Low beaver population from historic trapping activities	Improve LWD abundance through proper riparian zone management Encourage beaver population growth
Pool Frequency	6, 11, 16, 20, 22, 25, 28, 43, 44, 52	Low large woody debris abundance because of "clean outs"	Improve LWD abundance through proper riparian zone management Leave LWD in streams
Pool Quality	16, 52	Low large woody debris abundance because of "clean outs"	Improve LWD abundance through proper riparian zone management Leave LWD in streams
Streambank Stability	1, 6, 11, 12, 16, 17, 22, 33, 43, 44, 51, 52	Degraded riparian conditions caused by logging or development	Maintain riparian forest buffers along streams
Sediment Supply	6, 16, 18, 20, 22, 24-26	Mass wasting from logged forest land Eroding stream banks	Manage forest lands to prevent mass wasting caused by roads and logging on steep slopes Maintain riparian vegetation along streams
Mass Wasting	22, 24-26	Logging and road construction on steep slopes	Maintain forest cover on steep slopes and locate roads in geologically stable areas
Road Density	1-3, 6, 10, 11, 14, 16-26, 28-37, 39-41, 43-48, 51-56	Extensive logging activity Residential/urban development	Minimize the number of roads constructed in each watershed Decommission roads that are not currently in use
Riparian Condition	5-8, 11, 12, 15-17, 20, 25, 26, 43, 44, 51, 54	Historic logging along streams Residential, urban, and agricultural development	Protect riparian forest buffers Replant degraded areas to reestablish riparian forest buffers
Temperature	5-6, 18, 28, 35,	Degraded riparian buffer conditions Shallow man-made lakes	Protect riparian forest buffers and restore where necessary Do not construct shallow man-made lakes
Dissolved Oxygen	Data gap throughout report	Elevated water temperatures Elevated levels of organic matter or low flow conditions	Maintain riparian vegetation along streams, lakes, ponds, and wetlands Minimize nutrient inputs from animal/human wastes and fertilizer
Hydrologic Maturity	2, 8, 16, 19, 20, 26	Frequent logging over a large proportion of a watershed Conversion of forest land to residential land use	Manage timberlands on a sustainable basis to protect watershed functions Maintain timber production and concentrate residential growth to prevent sprawl

Habitat Limiting Factor	**Watershed (Rated Poor in** Table 14**)** Note: Legend to watershed numbers is located at end of table	**Potential Human-Induced Causes**	**Recommendations**
Percent Impervious Surfaces	Data gap in most of report	Concentrated residential or urban development Logging roads	Minimize impervious surfaces coverage and install remediation facilities (i.e. swales, wetlands, retention ponds) to offset impacts caused by impervious surfaces
Nutrients	13, 46, 53, 54, Data gap in most of report	Low abundance of returning adult anadromous salmonids	Manage anadromous salmonid populations to ensure sufficient escapement to meet nutrient needs of the watershed
Biological Diversity	13, 46, 53, 54, Data gap in most of report	Presence of introduced plants or animals Low abundance or extirpation of native plants or animals	Prevent introduction of exotic plants and animals, eliminate these species when necessary Practice management strategies that maintain the viability of native plant and animal populations

Legend

1. Hawks Hole Creek
2. Streams 15.0348 & 15.0349
3. Little Boston Creek
4. Middle Creek
5. Martha John Creek
6. Gamble Creek
7. Todhunter Creek
8. Ladine DeCouteau Creek
9. Machias Creek
10. Spring Creek
11. Cougar Creek & Kinman Creek
12. Jump Off Joe Creek
13. Cattail Creek
14. Devils Hole Creek
15. Unnamed Stream 15.0376
16. Little Anderson Creek
17. Johnson Creek
18. Big Beef Creek
19. Little Beef Creek
20. Seabeck Creek
21. Stream 15.0403
22. Stavis Creek
23. Boyce Creek
24. Harding Creek
25. Anderson Creek
26. Thomas Creek
27. Unnamed Stream 15.0418
28. Dewatto River
29. Little Dewatto Creek
30. Rendsland Creek
31. Browns Creek
32. Caldervin Creek
33. Lower Tahuya River
34. Middle Tahuya River
35. Upper Tahuya River
36. Shoofly Creek
37. Little Shoofly Creek
38. Cady Creek
39. Northshore Nursery Creek
40. Stimson Creek
41. Sundstrom Creek
42. Little Mission Creek
43. Big Mission Creek
44. Union River
45. Lynch Cove Tributaries
46. Devereaux Creek
47. Springbrook (Lakewood) Creek
48. Holyoke Creek
49. Unnamed Stream 14.0129
50. Unnamed Stream 14.0130
51. Twanoh Falls Creek
52. Twanoh Creek
53. Nordstrom Creek
54. Alderbrook Creek
55. Dalby Creek
56. Big Bend Creek

DATA GAPS

Little habitat condition information was available for small independent streams in the Port Gamble, Tahuya-Dewatto, Union-Mission, and North WRIA 14 Subbasins.

No escapement data were located for the report area.

Little water quantity information was available. The majority of stream flow data were gathered from the mid-1940s to the late 1950s.

With the exception of streams in the Port Gamble and Big Beef-Anderson Subbasins, and the Dewatto and Tahuya Rivers, little water quality information was available.

NEARSHORE HABITAT LIMITING FACTORS

Nearshore Introduction

Shoreline roads along Hood Canal have had a major influence on development along the Canal. The narrow strip of land waterward of roads was purchased for home sites and tidelands were filled to create additional room for development. Shoreline development along the Canal has caused destruction of tidelands, degradation of water quality, and loss of fish and wildlife resources (Yoshinaka and Ellifrit 1973). Filling of tidelands and shoreline armoring have been the most conspicuous shoreline alterations along the Canal. By the early 1970s, nearly 1,000 bulkheads and fills were estimated to have altered about 50% of the shoreline of the eastern arm of Hood Canal, virtually eliminating the natural shoreline in some areas (Yoshinaka and Ellifrit 1973). In the year 2000, bulkheads were present along more than 70% of the south shore of Hood Canal (Hirschi *et al.* 2002). Shoreline development and associated shoreline armoring affect anadromous salmonid production by disrupting nearshore habitat processes, reducing forage fish production, and altering salmonid behavior.

- Bulkheads prevent recruitment of sediment and large woody debris from bluffs and alter littoral transport of sediments and woody debris. Sediment recruited from bluffs and transported along the shoreline through littoral drift is necessary to maintain nearshore habitat features including beaches, spits, berms, and lagoons, all of which are important nearshore habitats. Littoral drift often carries sediments long distances from the recruitment source (i.e. bluff). Because of this the impacts of impaired sediment recruitment may appear far down drift from the site of impaired sediment recruitment, rather than at the site itself (TAG 2003).
- Surf smelt and sand lance, important forage fish for anadromous salmonid production, spawn near the high tide line of sand and gravel beaches. Intertidal fill and associated bulkheads reduce forage fish production through physical burial of spawning beaches, removal of riparian vegetation (which contributes to egg mortality), and coarsening of beach sediments (which eliminates spawning substrate) (Penttila 2001).
- Juvenile salmonids typically migrate through shallow water along the shoreline, feeding on aquatic invertebrates that live in eelgrass beds, and terrestrial invertebrates that fall off of riparian vegetation. The shallow nearshore environment also provides protection from predators that live in deeper water offshore. Overwater structures can shade out eelgrass beds, reducing forage abundance and cover needed by juvenile salmonids. Intertidal fill and bulkheads eliminate shallow water habitat, forcing juveniles into deeper water where they are more susceptible to predation. Removal of riparian vegetation eliminates habitat that would provide a terrestrial invertebrate food source (Simenstad 2000).

General Nearshore Recommendations

As noted earlier, the Hood Canal shoreline is a popular site for residential development. Filling of intertidal mudflat, salt marsh, and lagoon habitats, shoreline armoring, removal of riparian vegetation, and installation of boat ramps, docks, and piers, all associated with shoreline development, have altered natural shoreline processes including sediment recruitment from eroding bluffs and sediment transport and deposition along beaches. Shoreline development has also completely eliminated a substantial amount of nearshore/estuarine habitat that historically provided important forage fish spawning beaches and juvenile salmonid rearing and migration areas. Numerous roads and highways are located along the Hood Canal shoreline. In many cases, road crossings at stream mouths have constrained stream and tidal channels. These constrictions alter tidal processes and sediment transport, and in some cases interfere with anadromous fish migration. Shoreline roads have reduced the width of riparian buffers throughout much of the report area, particularly along the east arm of the Canal. While continued shoreline development is inevitable, the TAG makes the following recommendations to protect existing habitat and minimize further degradation:

- Protect existing functional nearshore habitats including: bluffs, bays, lagoons, salt marshes, spits, mudflats, and native riparian vegetation. Notable examples of each of these habitats include *(ordered from north to south)*:
  - Bluffs:
    - See eroding bluff section below.
  - Bays:
    - Gamble Bay
    - Big Beef Harbor
    - Seabeck Bay
    - Stavis Bay
    - Dewatto Bay
    - Tahuya Bay
  - Lagoons:
    - Foulweather Nature Conservancy Property
    - Lagoon 0.5 miles south of King Spit
    - Nick's Lagoon (Seabeck Bay)
    - Misery Point Lagoon
    - Lagoons between Misery Point and Stavis Bay
  - Salt Marshes:
    - Foulweather Bluff salt marsh
    - Foulweather Nature Conservancy Property
    - Small patches in the Driftwood Key Development (Coon Bay)
    - Mouth of Hawks Hole Creek
    - Point Julia
    - King Spit
    - Mouth of stream 15.0376
    - Mouth of Little Anderson Creek
    - Big Beef Harbor
    - Little Beef Harbor
    - Nick's Lagoon
    - Stavis Bay
    - Hood Point

        - Mouth of Boyce Creek
        - Tekiu Point
        - Mouth of Anderson Creek
        - Chinom Point
        - Mouth of Dewatto River
        - Mouth of Little Dewatto Creek
        - Mouth of Rendsland Creek
        - Mouth of Tahuya River
        - Lynch Cove
        - Mouth of Dalby Creek
    - Spits:
        - Foulweather Bluff salt marsh
        - Mouth of Gamble Creek
        - Misery Point
        - Stavis Bay
        - Mouth of Devereaux Creek
    - Mudflats:
        - Gamble Bay
        - Big Beef Harbor
        - Little Beef Harbor
        - Seabeck Bay
        - Stavis Bay
        - Dewatto Bay
        - Tahuya Bay
        - Lynch Cove
    - Native Riparian Vegetation:
        - Foulweather Bluff salt marsh
        - Foulweather Nature Conservancy property and shoreline immediately to the north and south
        - North shore of Stavis Bay north to Spear-Fir Lagoon
        - Community of Holly south to Bald Point
- Evaluate all road crossings along the Hood Canal shoreline to assess tidal function, sediment transport, and anadromous fish migration, and where necessary, implement corrective actions to restore and/or enhance natural tidal processes, sediment transport, and anadromous fish access.

- Allow eroding bluffs to function naturally to provide the sediment and large woody debris needed to maintain shoreline features such as beaches, spits, and lagoons, and shoreline habitat complexity. Notable eroding bluffs include:
    - Between the Foulweather Bluff salt marsh and the Foulweather Nature Conservancy property
    - Just south of Stavis Bay
    - Just south of the mouth of Boyce Creek
    - Just north of the mouth of Harding Creek

- Where practical, remove intertidal fill to restore/improve natural tidal and sediment transport processes.

- Where practical, remove shoreline armoring or replace armor with alternatives including large woody debris and riparian plantings.

- Prevent installation of intertidal fill and shoreline armoring, prevent removal of native riparian vegetation, and encourage landowners to install community boat ramps, docks, and piers rather than installing structures at each individual property.

- Encourage landowners to minimize disturbance of native riparian vegetation.

- Properly treat stormwater and wastewater to protect water quality.

- Reduce impervious surfaces and minimize the installation of additional impervious surfaces to reduce water pollution caused by stormwater runoff and reduce the impacts of high winter flows and low summer flows caused by reduced infiltration of precipitation.

- Remove unused creosoted pilings.

The following sections are organized similar to the riverine habitat portion of the report. The discussion begins at Foulweather Bluff at the extreme north end of west WRIA 15 and ends at the town of Union at the west end of north WRIA 14. Refer to Maps 8 and 9 to locate individual driftcells. Note that driftcell numbers change at the Kitsap-Mason County line. When oblique aerial photos are referenced (Washington Department of Ecology 2000b), note that file names of photos in the Mason County portion of the report area begin with the prefix *"010626,"* while photos in the Kitsap County portion of the report area begin with the prefix *"010426."* These prefixes were not included in photo cross-references for the sake of brevity.

Foulweather Bluff to Point Julia (Driftcells 1411 through 1420)

Shoreline Armoring

Although bulkheads were present along 20.2% of this shoreline, the vast majority are located within the Driftwood Key development at Coon Bay. The backshore zone was comprised of 6,417 meters of high bluff, 1,500 meters of low bluff, 4,306 meters of beaches/spits/berms, and 2,304 meters of uplands (Hirschi *et al.* 2002). See Table 16 for the shoreline characteristics of individual driftcells along this reach. A riprap bulkhead prevents sediment recruitment from a bluff about one mile (measured along shoreline) south of the Foulweather Bluff salt marsh (Washington Department of Ecology 2000b). See oblique photo #142802. Riprap on the smaller cuspate spit may alter sediment deposition (Brocksmith 2003, Personal communication). See oblique photo #142740. Numerous bulkheads have been constructed along the shoreline of Coon Bay (Driftwood

Key community) (Washington Department of Ecology 2000b, Hirschi *et al.* 2002). A portion of a bluff just south of Coon Bay is completely armored with riprap, blocking sediment recruitment (Washington Department of Ecology 2000b). See oblique photo #14230. In addition, fill and riprap on the Driftwood Key Peninsula have truncated sediment deposition (Brocksmith 2003, Personal communication). See oblique photo #143022. From Hawks Hole Creek south to Point Julia, there are few bulkheads to interrupt sediment processes (Washington Department of Ecology 2000b).

<u>Docks and Piers</u>

A total of 46 docks, three launch ramps, one rail launch, and 11 stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell along this shoreline. A large marina and numerous docks have been constructed in Coon Bay (Driftwood Key community) (Washington Department of Ecology 2000b), the former site of an intertidal lagoon and accretion spit (Point No Point Treaty Council 2003, Unpublished work). Three boat ramps and a long pier are currently in use on Point Julia (Washington Department of Ecology 2000b).

<u>Stormwater/Wastewater</u>

Roads, cleared land, roof tops, and driveways in the Driftwood Key housing development likely accelerate stormwater runoff and channel pollutants to Hood Canal (TAG 2003). Drainage alterations (i.e. runoff collected in a drainage system and released via pipes, versus runoff that disperses across the surface and infiltrates the soil) at residences built atop bluffs from Hawks Hole Creek south to Point Julia may increase bluff stability (evidenced by immature alders growing at the bases of bluffs), thereby reducing sediment and LWD recruitment (TAG 2003).

<u>Landfill</u>

Historically, a 1.5 acre lagoon fringed by a 0.9 acre salt marsh, and a 1.0 acre grassy berm were present on the spit about 0.5 miles due south of the Foulweather Bluff salt marsh (Point No Point Treaty Council 2003, Unpublished work). This habitat was completely lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #142730. The salt marsh and enclosed lagoon at the Foulweather Nature Conservancy property historically appeared to be a freshmarsh with no open water (Point No Point Treaty Council 2003, Unpublished work). The present lagoon may have been constructed in the early 1900s for log storage (TAG 2003). However, no information is available at this time to explain the historical discrepancy (Brocksmith 2003, Personal communication). A 37.5 acre lagoon fringed by 18 acres of wetlands and 2.8 acres of salt marsh was historically present at Coon Bay (Driftwood Key) (Point No Point Treaty Council 2003, Unpublished work). Portions of the lagoon and nearly all of the wetlands and salt marsh have been lost to filling and residential development. The majority of the historic mudflats are still present (Washington Department of Ecology 2000b), although dredging has converted intertidal mudflats to subtidal mudflats with unknown effects on salmonids and their habitat. The loss of shallow water habitat to filling impedes salmonid migration (TAG 2003). See oblique photo #142936. The current Point Julia salt marsh is similar in size to the historic extent. A grassy berm was historically present along the southern margin of the point (Point No

Point Treaty Council 2003, Unpublished work). Part of this berm has been converted to an access road and parking lot at a boat launch (Washington Department of Ecology 2000b). See oblique photo #143440.

Riparian Buffers

Residential land use is the dominant land use within the riparian zone along this shoreline. Riparian buffers at the Foulweather Bluff salt marsh and Foulweather Nature Conservancy salt marsh are comprised of dense and mature stands of second growth coniferous and deciduous trees (Washington Department of Ecology 2000b). From Foulweather Bluff south to Coon Bay, riparian buffers are sparse to non-existent where residential development is present. Native riparian vegetation along the shoreline of Coon Bay has been completed eliminated and replaced with lawns, bulkheads, and docks (Washington Department of Ecology 2000b). Immature alders are present along the base of bluffs from Hawks Hole Creek south to Point Julia. The riparian forest on top of the bluffs is a patchwork of cleared lots and mature timber (Washington Department of Ecology 2000b). A combination of static bluffs (via stormwater rerouting), bulkheads, and possibly reduction of fetch by the Hood Canal Bridge has limited woody debris and sediment recruitment along this shoreline (Brocksmith 2003, Personal communication).

Tidal Processes

The Foulweather Bluff salt marsh complex appears much the same today as it did during the first surveys conducted in the 1880s (Point No Point Treaty Council 2003, Unpublished work). A substantial amount of large woody debris has accumulated in the northeast corner of the salt marsh (Washington Department of Ecology 2000b). See oblique photo #142712. An accumulation of this magnitude is believed to be unnatural, possibly the result of wood lost from broken log rafts. In the case of naturally derived LWD, many pieces would contain both the bole and rootwad of the tree. If this were the case, the log would be deposited on the spit, not on the surface of the salt marsh. About 90% of these woody debris pieces are in fact cut logs (Brocksmith 2003, Personal communication). It is not known what effect these logs may be having on the current and future ecological function of the marsh (TAG 2003). A 37.5 acre lagoon was historically present at Coon Bay (Driftwood Key) (Point No Point Treaty Council 2003, Unpublished work). Dredging of the lagoon created the two deep-water moorages present today (Washington Department of Ecology 2000b). A grassy accretion spit, 0.9 acre lagoon, and 3.7 acre salt marsh were historically present north of the present mouth of Hawks Hole Creek (Point No Point Treaty Council 2003, Unpublished work). The spit and lagoon are no longer present (Washington Department of Ecology 2000b). The salt marsh was lost to fill at a community park (Brocksmith 2003, Personal communication). See oblique photo #143238. The cause of this loss is unknown, but the TAG speculates that one factor may have been reduced sediment recruitment updrift (south) of Hawks Hole Creek, leading to sediment depletion and eventual complete erosion of the spit. In addition to bulkheads and stormwater rerouting, the Hood Canal floating bridge may limit wave energy, reducing sediment transport capacity (TAG 2003). An access area on the south side of the mouth of Shipbuilders Creek (15.0349) constricts the mouth of the stream, while concrete debris may also inhibit salmonid migration and sediment processes (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Restore lost salt marsh and lagoon habitat at the spit 0.5 miles south of the Foulweather Bluff salt marsh. Restore sediment depositional processes by removing bulkheads at this spit.
- Assess geomorphic history of Foulweather Nature Conservancy marsh and improve functions.
- Explore options to restore lost riparian, salt marsh, lagoon, and intertidal habitat at Driftwood Key (Coon Bay).
- Restore tidal influence, salt marsh, and spit habitats at Hawks Hole Creek.
- Remove the impacts to habitat forming processes at access area south of the mouth of Shipbuilders Creek.
- Remove abandoned barge just north of Point Julia
- On Point Julia, remove the north boat ramp and associated bridge over a tidal channel; reduce total boat ramps to one; minimize the footprint of the road, parking lot, and fill; remove unused materials along the access road to encourage revegetation.
- Evaluate effects of Hood Canal Floating Bridge on wave energy/sediment transport north of the bridge, and redesign bridge or its operations as needed.

Table 16. Foulweather Bluff to Point Julia Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1411	0.0	669	339	0	330	0	0	Counter-clockwise
1412	0.0	217	0	0	217	0	0	Undefined
1413	9.1	3,116	1,256	279	1,440	0	142	Clockwise
1414	0.0	409	409	0	0	0	0	Divergence Zone
1415	14.2	997	153	460	384	0	0	Counter-clockwise
1416	71.2	2,798	0	0	636	0	2,162	Undefined
1417	15.8	3,239	2,017	761	461	0	0	Clockwise
1418	0.0	530	530	0	0	0	0	Divergence Zone
1419	3.8	2,451	1,713	0	738	0	0	Counter-clockwise
1420	0.0	100	0	0	100	0	0	Undefined
Totals	20.2	14,526	6,417	1,500	4,306	0	2,304	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Point Julia to Teekalet Bluff (Driftcells 1421 through 1426)

Shoreline Armoring

Bulkheads were present along 13.7% of this shoreline. The backshore zone consisted of 5,936 meters of high bluff, 1,520 meters of low bluff, 1,666 meters of beaches/spits/berms, and 4,442 meters of uplands (Hirschi *et al.* 2002). See Table 17 for shoreline characteristics of individual driftcells along this reach. Riprap bulkheads have been installed along the toe of a low bluff about 1.5 miles south of Point Julia. Homes along this shoreline are set back from the rim of the bluff such that bulkhead removal or modification may be feasible. Bulkheads have also been installed along the shorelines north and south of the inlets of Gamble and Martha John Creeks (Washington Department of Ecology 2000b, Hirschi *et al.* 2002).

Docks and Piers

A total of eight docks, one jetty, one launch ramp, and 13 sets of stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures in each driftcell along this shoreline. Some old pilings are present about 0.7 miles south of Point Julia. See oblique photo #143500. Some overwater structures and grounding docks are present at the mouth of Martha John Creek. An old section of the Hood Canal floating bridge, a large number of old pilings, and an abandoned dock are present on the west shoreline about 1.3 miles north of the head of Gamble Bay. See oblique photo #143956 (Washington Department of Ecology 2000b). The majority of the shoreline at the Port Gamble log yard consists of abandoned piers, pilings, and overwater structures (Washington Department of Ecology 2000b). See oblique photo #144032.

Stormwater/Wastewater

Cleared land, roads, driveways, and rooftops associated with residential development along this shoreline are likely to accelerate stormwater runoff and channel pollutants to Gamble Bay. Homes located close to the shoreline may contribute wastewater from septic systems (TAG 2003).

Landfill

The mouth of Gamble Creek remains largely unchanged from historic conditions. The mudflats and spit present today are very similar to the features mapped in the 1800s (Point No Point Treaty Council 2003, Unpublished work). Some fill is present adjacent to an abandoned dock on the west shoreline about 1.3 miles north of the head of Gamble Bay (Washington Department of Ecology 2000b). The Port Gamble log yard and mill are located on fill placed on mudflats and an accretion spit west of Point Julia (Point No Point Treaty Council 2003, Unpublished work).

Riparian Buffers

Residential land use is the dominant land use in the riparian zone along the east shore of Gamble Bay. Deciduous trees are the dominant forest vegetation along the shoreline from Point Julia south to Gamble Creek. Native riparian vegetation is sparse to non-existent at many of the developed home sites along this shoreline. However, banks are relatively well-vegetated. Patches of coniferous forest are scattered among the residences. Industry, forestry, and transportation are the dominant land uses along the west shore of Gamble Bay. Forests composed of a mix of deciduous and coniferous trees dominate the riparian buffer from the mouth of Gamble Creek to Port Gamble. Deciduous trees and lawns are the dominant riparian vegetation just north of the mouth of Gamble Creek and adjacent to the Port Gamble Mill log yard (Washington Department of Ecology 2000b).

Tidal Processes

Landfill, a weir, and other structures at the Little Boston Creek hatchery limit tidal processes and obstruct anadromous fish passage (Washington Department of Ecology 2000b). With the exception of the mouth of Little Boston Creek, tidal processes appear to be largely unimpacted by human development (Washington Department of Ecology 2000b). A culvert at the mouth of Gamble Creek may alter tidal influence and sediment processes (TAG 2003).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Restore tidal processes and fish access in Little Boston Creek.
- Remove old pilings about 0.7 miles south of Point Julia.
- Protect the inlet of Martha John Creek and remove overwater structures and grounding docks at the mouth of the stream.
- Evaluate potential impacts of culvert at the mouth of Gamble Creek, and redesign as necessary.
- Remove old pilings, abandoned dock, and fill on the west shoreline about 1.3 miles north of the head of Gamble Bay.
- Remove old section of the Hood Canal floating bridge from the west shore of Gamble Bay.
- Remove intertidal fill, armoring, log storage debris, and pilings at the Port Gamble Log Mill to restore intertidal habitat.
- Remove intertidal fill and armoring of jetty/breakwater to restore sediment processes at Port Gamble Point. Restore riparian zone.

Table 17. Point Julia to Teekalet Bluff Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1421	4.3	2,584	2,222	0	362	0	0	Clockwise
1422	0.6	564	448	117	0	0	0	Divergence Zone
1423	36.3	3,018	0	1,403	133	0	1,481	Counter-clockwise
1424	1.5	1,625	0	0	512	0	1,113	Undefined net shore drift
1425	18.7	1,699	852	0	546	0	301	Clockwise
1426	7.6	4,074	2,414	0	113	0	1,547	No appreciable net shore drift
Totals	13.7	13,564	5,936	1,520	1,666	0	4,442	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Teekalet Bluff to Warrenville Mudflat (Driftcell 1427-1429)

Shoreline Armoring

Bulkheads were present along 22.9% of this shoreline. The backshore zone was comprised of 14,954 meters of high bluff, 5,963 meters of low bluff, 3,953 meters of beaches/spits/berms, 52 meters of salt marsh, and 2,655 meters of uplands (Hirschi *et al.* 2002). See Table 18 for shoreline characteristics of individual driftcells along this reach. Bulkheads protect a large number of properties in this extensively developed residential area. A bulkhead blocks sediment recruitment from a low bluff about 0.3 miles south of the Hood Canal Bridge. Numerous bulkheads are present from Spring Creek south to Jump Off Joe Creek. More than 1,000 feet of creosoted bulkhead is in use at the base of a low bluff at Kitsap Memorial Park. Shoreline armoring is limited on the Bangor Naval Station, but a road in the backshore zone limits sediment recruitment and fragments the riparian buffer (Washington Department of Ecology 2000b).

Docks and Piers

A total of 17 docks, seven launch ramps, nine rail launches, and 51 sets of stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell. Three boat ramps and one dock are in use at Salsbury Point County Park. Several rail launches are in use at the community of Vinland (Washington Department of Ecology 2000b). Overwater structures associated with the Bangor Naval Station may limit eelgrass production and alter juvenile salmonid migration patterns (TAG 2003).

Stormwater/Wastewater

Numerous roads, driveways, clearings, and rooftops associated with residential development likely accelerate stormwater runoff and channel pollution to nearby streams and Hood Canal. A large amount of impervious surfaces are present on the Bangor Naval Station. These surfaces likely accelerate stormwater runoff and channel pollution to the

Canal. Historic hazardous waste dumps on the sub-base should be monitored (TAG 2003).

Landfill

A nine acre salt marsh, 1.2 acre freshwater marsh, and lagoon were historically present at Salsbury Point (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #144148. A 1.2 acre salt marsh was historically present south of the mouth of Spring Creek (Point No Point Treaty Council 2003, Unpublished work). The majority of this habitat was lost to filling and residential development. A remnant salt marsh is still present (Washington Department of Ecology 2000b). See oblique photo #144300. A 1.6 acre salt marsh was historically present at the mouth of Kinman Creek (Point No Point Treaty Council 2003, Unpublished work). Most of this habitat was lost to filling and residential development (Washington Department of Ecology 2000b). Tidal influence to the remaining marsh was reduced by the fill, converting the remnant marsh to a brackish marsh (Small 2003, Personal communication). See oblique photo #144400. An intertidal bulkhead and fill are present immediately south of Kitsap Memorial Park. See oblique photo #144408. The Lofall ferry terminal was built on intertidal fill (Washington Department of Ecology 2000b). See oblique photo #144410. A 5.6 acre salt marsh was historically located about 0.3 miles south of the Lofall ferry terminal (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #144414. A 4.7 acre salt marsh was historically present on Floral Point (south of Cattail Creek) (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to fill and a road (Washington Department of Ecology 2000b). Two accretion spits and an 8.2 acre intertidal lagoon were historically present at the mouth of Devils Hole Creek (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost when a road was constructed on a filled causeway, creating Devils Hole Lake (Washington Department of Ecology 2000b).

Riparian Buffers

Residential land use is the dominant land use in the northern portion of this reach. Military land use dominates the southern portion of the reach. A narrow band of mixed coniferous and deciduous forest is present in the riparian zone from the Port Gamble Mill to Salsbury Point. All native riparian vegetation has been replaced by lawns at Salsbury Point. Deciduous trees with patches of coniferous trees and lawns are the dominant riparian vegetation from Salsbury Point south to Spring Creek. Native riparian vegetation has been replaced with lawns along the majority of the shoreline from Spring Creek south to the community of Vinland. A few patches of mature coniferous trees remain on undeveloped property. A road in the backshore zone on the Bangor Naval Station limits width of the riparian buffer. Although the buffer is narrow, there is potential for restoration. Deciduous trees with patches of conifers are the dominant riparian vegetation from the community of Bangor south to the community of Warrenville. Native riparian vegetation has been cleared from many residential lots along this shoreline (Washington Department of Ecology 2000b).

Tidal Processes

A 3.4 acre salt marsh and 0.7 acre lagoon were historically present at the mouth of Cattail Creek (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #144648. This habitat was lost when Cattail Lake was created by construction of a road built over a filled causeway. King Spit (near the community of Bangor) remains in a nearly natural condition with moderate impacts from a road berm. A large amount of LWD has accumulated on the spit. See oblique photo #144924. A lagoon is present about 0.5 miles south of King Spit. See oblique photo #145006. A small salt marsh is present south of the mouth of stream 15.0376 (Washington Department of Ecology 2000b), but the tidal prism has been altered by a bulkhead and lawn (Brocksmith 2003, Personal communication). See oblique photo #145116.

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove east boat ramp at Kitsap County Park on Salsbury Point, revegetate riparian zone with native plants.
- Where possible, restore riparian vegetation at the mouth of Kinman Creek and improve tidal influence to the stream.
- Remove creosote bulkhead to restore sediment recruitment and riparian processes along ~1000 ft of shoreline at Kitsap Memorial State Park.
- Remove the Lofall ferry terminal.
- Restore salt marsh and lagoon habitat; restore fish passage at the mouth of Cattail Creek.
- Manage Floral Point remediation/restoration site to limit containment but improve riparian and sediment processes.
- Minimize impacts to the photic zone and the juvenile salmonid migratory corridor by over water structures on the Bangor Naval Station.
- Minimize stormwater impacts from impervious surfaces on Bangor Naval Station.
- Remove road and fill to restore accretion spits and intertidal lagoon at Devil's Hole Creek.
- Remove old pilings north of King Spit.
- Investigate and reduce potential impacts from berm on north edge of King Spit.

Table 18. Teekalet Bluff to Warrenville Mudflat Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1427	22.9	27,885	14,954	5,963	3,953	52	2,655	Clockwise
1428	22.9	-	-	-	-	-	-	Clockwise
1429	22.9	-	-	-	-	-	-	Clockwise
Totals	22.9	27,885	14,954	5,963	3,953	52	2,655	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Warrenville Mudflat to Misery Point (Driftcells 1430 through 1433)

Shoreline Armoring

Bulkheads were present along 41.5% of this shoreline. The backshore consisted of 1,143 meters of high bluff, 7,790 meters of low bluff, 956 meters of beaches/spits/berms, 1,627 meters of salt marsh, and 2,101 meters of uplands (Hirschi *et al.* 2002). See Table 19 for shoreline characteristics of individual driftcells along this reach. Numerous bulkheads are present north of the mouth of Little Anderson Creek. Several bulkheads are present north and south of the mouth of Johnson Creek. Numerous bulkheads are present from Johnson Creek to Misery Point (Washington Department of Ecology 2000b). Bulkheads in the vicinity of the Seabeck Marina are impacting forage fish which are documented to spawn on these beaches (Small 2003, Personal communication).

Docks and Piers

A total of 21 docks, three launch ramps, 18 rail launches, and eight stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell. The Seabeck Marina is also located along this reach (TAG 2003).

Stormwater/Wastewater

Roads, driveways, and rooftops associated with residential development likely accelerate stormwater runoff and channel pollutants to nearby streams and Hood Canal. The Seabeck Marina is built with creosoted pilings. The marina also has problems with floating debris and sewage disposal (TAG 2003).

Landfill

A 0.5 acre salt marsh was historically present just northeast (~100m) of the Little Anderson Creek salt marsh (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #145148. A 0.3 acre salt marsh was historically present at the mouth of Johnson Creek (Point No Point Treaty Council 2003, Unpublished work). This habitat has been converted to two in-channel ponds (Washington Department of Ecology 2000b). See oblique photo #145216. A spit and 0.8 acre salt marsh were historically present at the mouth of Big Beef Creek (Point No Point Treaty Council 2003, Unpublished work). The spit was buried by fill placed in the causeway under the Seabeck Highway, and the salt marsh was lost to residential development (Washington Department of Ecology 2000b). About 3% of the historic Big Beef Creek Delta has been lost because of filling and pond construction undertaken by the UW Big Beef Research Station. The WDFW weir alters sediment transport into the estuary. The Seabeck Road Bridge and causeway have narrowed the opening of the estuary, leading to reduced tidal exchange and filling of the estuary with sediment (Ames *et al.* 2000). See oblique photo #145346. The pond at the Seabeck Conference Center was historically a lagoon. The Seabeck Highway was built on top of the historic location of a spit (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #145628. About 9% of the historic area of the Seabeck Creek Delta has been filled for recreational and commercial use. Residential development appears to have removed a significant portion of the historic summer chum rearing area (Ames *et al.* 2000).

Riparian Buffers

Residential land use and roads are the dominant land uses within the riparian zone along this reach. Immature deciduous trees and lawns are the dominant riparian vegetation along the shoreline. A few patches of conifers are scattered on undeveloped properties, particularly between Nick's Lagoon and Misery Point (Washington Department of Ecology 2000b).

Tidal Processes

A salt marsh at the mouth of Little Anderson Creek appears much the same as it did when mapped in the 1800s (Point No Point Treaty Council 2003, Unpublished work). The causeway under the Seabeck Highway has substantially narrowed the mouth of Big Beef Creek (Point No Point Treaty Council 2003, Unpublished work), reducing tidal influence upstream and altering sedimentation rates in the bay (TAG 2003). A salt marsh at Nick's Lagoon appears to have diminished in size and quality as a result of filling when the site was a historic log yard (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150048. A spit with a lagoon and salt marsh at Misery Point appear much the same today as they did when first mapped in the 1800s (Washington Department of Ecology 2000b, Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150124.

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Restore lost salt marsh habitat about 100 meters northeast of the Little Anderson Creek salt marsh.
- Remove roads in the Little Anderson Creek Subestuary.
- Restore tidal processes, and lost salt marsh habitat at the mouth of Johnson Creek.
- Restore natural tidal influence and sediment transport in the Big Beef Creek subestuary.
- Remove road fill and structures on historic spit feature at Seabeck to restore sediment and tidal processes.
- Restore intertidal wetlands and salt marsh at Nick's Lagoon by removing log structures and associated fill; remove derelict boats and other refuse.

Table 19. Warrenville Mudflat to Misery Point Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1430	71.6	748	141	607	0	0	0	Divergence Zone
1431	45.7	9,467	992	5,791	592	146	1,946	Counter-clockwise
1432	1.4	576	0	0	0	576	0	Undefined
1433	22.0	2,826	10	1,392	364	905	155	Clockwise
Totals	41.5	13,617	1,143	7,790	956	1,627	2,101	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Misery Point to Hood Point (Driftcells 1434 through 1440)

Shoreline Armoring

Bulkheads were present along 12.9% of this shoreline. The backshore zone was comprised of 4,545 meters of high bluff, 3,660 meters of low bluff, 2,313 meters of beaches/spits/berms, 361 meters of salt marsh, and 1,289 meters of uplands (Hirschi *et al.* 2002). See Table 20 for the shoreline characteristics of individual driftcells along this reach. Several bulkheads are present to the north and south of the WDFW Misery Point boat launch. Bulkheads to the north block sediment recruitment from a bluff (Washington Department of Ecology 2000b). See oblique photo #150214. A bulkhead at Scenic Beach State Park protects a handicapped accessible ramp to the beach. Old concrete foundations limit bluff erosion north of the small unnamed stream at Scenic Beach State Park (TAG 2003). A bulkhead prevents sediment recruitment from a bluff about 0.5 miles north of Hood Point (Washington Department of Ecology 2000b). See oblique photo #150726.

Docks and Piers

A total of one launch ramp and nine sets of stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell along this shoreline.

Stormwater/Wastewater

Land clearing, roads, driveways, and rooftops associated with residential development likely accelerate stormwater runoff and channel pollutants to Hood Canal. Septic systems at shoreline homes may contribute wastewater to Hood Canal (TAG 2003).

Landfill

A 4.7 acre salt marsh and intertidal lagoon were historically present just south of the WDFW Misery Point Boat Launch at the community of Miami Beach (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #150222. Intertidal fill and a bulkhead are currently present (Washington Department of Ecology 2000b) at the historic site of a tidal channel that connected Spear-Fir lagoon with Stavis Bay (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150350. A home about 0.6 miles south of the mouth of Stavis Bay is constructed on intertidal fill protected by a bulkhead (Washington Department of Ecology 2000b). See oblique photo #150648.

Riparian Buffers

Residential land use is the dominant land use in the riparian zone along this stretch of shoreline. Coniferous trees dominant riparian vegetation from Misery Point south to Spear-Fir Lagoon. Residential development has degraded or removed native riparian vegetation on many properties along this stretch of shoreline. Trees have been cleared from the riparian buffer at Scenic Beach State Park. A mature coniferous forest lines the shoreline from Spear-Fir Lagoon south to the east shore of Stavis Bay. A mixed deciduous and coniferous forest lines the west shoreline of Stavis Bay. Mature coniferous trees with patches of deciduous trees are the dominant riparian vegetation from the mouth of Stavis Bay south to Hood Point (Washington Department of Ecology 2000b).

Tidal Processes

Two large spits historically extended across the outlet of Spear-Fir lagoon south across a second lagoon and into Stavis Bay. Surface water connection with the lagoon historically flowed through a channel between the existing shoreline and the lagoon (Point No Point Treaty Council 2003, Unpublished work). The spit is significantly reduced in size (Washington Department of Ecology 2000b). See oblique photo #150342. No historical information is available for the change in shoreline morphology, but historic land use, reduced sediment inputs, and the intertidal fill discussed above likely contributed to the reduction in spit size (TAG 2003). A small lagoon is still present adjacent to the filled area (Washington Department of Ecology 2000b), but its functions have been altered (Brocksmith 2003, Personal communication). Additional salt marsh habitat has formed west of the Stavis Bay Road bridge over Stavis Creek when compared to the habitat mapped in the 1800s (Point No Point Treaty Council 2003, Unpublished work). This bridge may limit tidal influence upstream, potentially leading to the replacement of tidal flat with salt marsh habitat downstream in Stavis Bay (TAG 2003). See oblique photo #150434. The Stavis Creek estuary provides abundant transitional areas for adult and juvenile salmonids (Ames *et al.* 2000). Several active feeder bluffs are present from the mouth of Stavis Bay south to Hood Point (Washington Department of Ecology 2000b). A home sits on top of a bluff slide bench about 0.4 miles north of Hood Point. This property is protected by a bulkhead that limits sediment recruitment from the bluff (Washington Department of Ecology 2000b). This home is likely to be destroyed by erosion of the bluff (TAG 2003). See oblique photo #150730.

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Acquire property south of WDFW Misery Point boat launch at Miami Beach to restore lost salt marsh, spit, and lagoon habitats. Restore sediment supply.
- Remove concrete foundations at base of bluff north of unnamed stream at Scenic Beach State Park and revegetate cleared riparian area with native plants.
- Remove intertidal fill at mouth of small lagoon between Spear-Fir Lagoon and Stavis Bay and restore sediment processes.

Table 20. Misery Point to Hood Point Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1434	3.8	193	193	0	0	0	0	Divergence Zone
1435	18.7	5,292	1,403	2,030	723	0	1,137	Counter-clockwise
1436	0.0	2,620	0	1,403	856	361	0	Undefined
1437	22.3	202	0	142	59	0	0	Clockwise
1438	10.4	331	245	85	0	0	0	Divergence Zone
1439	15.1	3,428	2,704	0	572	0	152	Counter-clockwise
1440	0.0	103	0	0	103	0	0	Undefined
Totals	12.9	12,169	4,545	3,660	2,313	361	1,289	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Hood Point to Anderson Cove (Driftcells 1441 through 1446)

Shoreline Armoring

Bulkheads were present along 16.5% of this shoreline. The backshore zone consisted of 5,764 meters of high bluff, 1,598 meters of low bluff, 910 meters of beaches/spits/berms, 14 meters of salt marsh, and 664 meters of uplands (Hirschi *et al.* 2002). Bulkheads and groins are present south of Hood Point (Washington Department of Ecology 2000b). A home is built on top of an active feeder bluff about 0.6 miles south of Hood Point. No armoring has been installed downslope from this home. See oblique photo #150840. About 0.2 miles south of the previous home, two more homes are located on a bluff. Bank protection downslope from one of the homes blocks sediment recruitment from the bluff (Washington Department of Ecology 2000b). See oblique photo #150846. A wooden seawall disrupts shoreline processes and prevents channel migration at the mouth of the unnamed/unnumbered stream south of Boyce Creek. The lower reaches of the stream are channelized. See oblique photo #150910. About 1.5 miles south of Boyce Creek, an access road along the shoreline is protected by a riprap bulkhead that prevents sediment recruitment from the adjacent bluff. See oblique photo #151420. A bulkhead protects residential property immediately south of Tekiu Point. See oblique photo #151506 (Washington Department of Ecology 2000b). See Table 21 for the shoreline characteristics of individual driftcells along this reach.

Docks and Piers

A total of two docks, and one set of stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell.

Stormwater/Wastewater

Stormwater impacts along the majority of this reach are presumed to be minimal because of low levels of development. Some homes are located in close proximity to the shoreline, possibly contributing wastewater to the Canal. Cleared land, roof tops, driveways, and roads associated with a group of homes just north of Anderson Cove likely accelerate stormwater runoff and contribute pollutants to the Canal (TAG 2003).

Landfill

Historically a 2.44 acre grassland spit, 2.6 acre lagoon, and 4.33 acre salt marsh complex were present on Hood Point (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to residential development and forest growth (Washington Department of Ecology 2000b). See oblique photo #150752. Some of the forest growth may be the result of natural vegetative succession following landfill (TAG 2003). The Boyce Creek estuary appears to contain the same amount of salt marsh (3.7 acres) as it did historically (Point No Point Treaty Council 2003, Unpublished work). However, this habitat has been degraded by landfill from an old log yard that operated in the estuary (Brocksmith 2003, Personal communication). A derelict beach house sits on the shoreline on the southeast corner of the Boyce Creek Delta. A home built on intertidal fill is located about 1.7 miles south of Boyce Creek. See oblique photo #151424. An abandoned home is located on the right bank of the mouth of Harding Creek. See oblique photo #151440. The majority of Tekiu Point is covered with salt marsh. See oblique photo #151506 (Washington Department of Ecology 2000b).

Riparian Buffers

The dominant riparian land use on this shoreline is changing from forestry to residential use. Riparian buffers along this reach are generally composed of a dense mix of coniferous and deciduous trees. Pockets of rural residential development have degraded or eliminated the buffer in some areas. Large woody debris is present on the beaches below many of the bluffs along this shoreline (Washington Department of Ecology 2000b).

Tidal Processes

Sediment retention structures (cut logs) were installed in the tidal channels at the mouth of Boyce Creek. This property is now a Kitsap County nature preserve (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove groins south of Hood Point.
- Remove log retention structures in the tidal channels on the Boyce Creek delta and convert derelict beach house to an interpretive center or remove.
- Remove wooden seawall and restore natural channel geometry at mouth of unnamed/unnumbered stream about 0.5 miles south of Boyce Creek.
- Acquire property 1.5 miles south of Boyce Creek and remove riprap to allow sediment recruitment from adjacent bluff; remove home landward out of the intertidal zone.
- Remove the abandoned home near the mouth of Harding Creek.

Table 21. Hood Point to Anderson Cove Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1441	18.5	3,836	2,674	447	546	0	170	Clockwise
1442	11.6	3,060	2,304	397	242	0	118	Counter-clockwise
1443	0.0	51	0	0	51	0	0	Undefined
1444	23.7	1,303	628	228	71	0	376	Clockwise
1445	15.7	275	158	118	0	0	0	Divergence Zone
1446	17.2	422	0	408	0	14	0	Counter-clockwise
Totals	16.5	8,947	5,764	1,598	910	14	664	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Anderson Cove to Chinom Point (Driftcells 1447 through 1451)

Shoreline Armoring

Hirschi *et al.* (2002) identified bulkheads along 9.6% of this shoreline. The backshore zone was comprised of 3,863 meters of high bluff, 543 meters of low bluff, 287 meters of beaches/spits/berms, 825 meters of salt marsh, and 1,559 meters of uplands (Hirschi *et al.* 2002). A retaining wall downslope from a home limits sediment recruitment from a bluff between Anderson Cove and Holly. See oblique photo #151640. A frontage road runs along the shoreline in the community of Holly. The road is protected by extensive bulkheads and is presently the only access to many of the homes located along the shoreline. See oblique photo #151848. See Table 22 for the shoreline characteristics of individual driftcells along this reach.

Docks and Piers

A total of one dock, and two launch ramps were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell.

Stormwater/Wastewater

Cleared land, rooftops, driveways, and roads at the community of Holly likely accelerate stormwater runoff and channel pollution to the Canal. Homes are located close to the shoreline, increasing the likelihood of wastewater reaching the Canal (TAG 2003). See oblique photo #151848.

Landfill

An old railroad or road grade protected by pilings bisects the head of Anderson Cove (Washington Department of Ecology 2000b). Intertidal habitat was lost to fill under the county road (TAG 2003). A one acre salt marsh and 0.2 acre lagoon were historically present at the mouth of Thomas Creek. Two additional salt marshes (0.5 acres and 1.0 acres) were historically present south of Thomas Creek in the community of Holly (Point No Point Treaty Council 2003, Unpublished work). All three salt marshes and the lagoon were lost to filling and residential development (Washington Department of Ecology 2000b).

Riparian Buffers

A county road fragments the riparian buffer along the north shore of Anderson Cove (Washington Department of Ecology 2000b). The exotic plant, Japanese Knotweed is present along the shoreline of Anderson Cove (TAG 2003). From the community of Holly south to Chinom Point, the riparian buffer is composed of a dense and mature forest of coniferous and deciduous trees. Residential development along this shoreline is very limited. Forestry is still the dominant land use (Washington Department of Ecology 2000b).

Tidal Processes

Natural tidal processes appear to be maintained along this segment with the exceptions of impacts caused by county roads and the railroad grade at Anderson Cove; and fill, residential development, and bulkheads at the community of Holly (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove old railroad grade and pilings from the head of Anderson Cove. Assess impacts to Holly Road.
- Eradicate invasive Japanese Knotweed from Anderson Cove.
- Remove the county road along the north shore of Anderson Cove (traffic could be rerouted to the road immediately to the north) and revegetate the riparian zone with native plants.
- Restore historic salt marsh and lagoon habitats at the community of Holly.
- Protect the remaining salt marsh habitat on Chinom Point. Approach the landowner regarding restoration of lost salt marsh habitat, natural intertidal function, and natural channel morphology of the small stream on the north side of the point.

Table 22. Anderson Cove to Chinom Point Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1447	0.0	860	0	112	0	748	0	Undefined
1448	20.7	3,373	1,607	431	0	77	1,259	Clockwise
1449	0.0	998	998	0	0	0	0	Divergence Zone
1450	0.0	1,753	1,258	0	195	0	300	Counter-clockwise
1451	0.0	92	0	0	92	0	0	Undefined
Totals	9.6	7,076	3,863	543	287	825	1,559	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Chinom Point to mouth of Dewatto Bay (Driftcells 1452 through 1238)

Shoreline Armoring

Bulkheads were present along only 0.6% of this shoreline. The backshore zone was comprised of 8,156 meters of high bluff, 384 meters of low bluff, 384 meters of beaches/spits/berms, and 114 meters of uplands (Hirschi *et al.* 2002). A low elevation bulkhead is present about 1.2 miles north of the mouth of Dewatto Bay. See oblique photo #144322. The mouth of an unnamed stream about one mile north of the mouth of Dewatto Bay has been channelized (Washington Department of Ecology 2000b). See oblique photo #144332. Bulkheads have been installed downslope from two homes located about 0.75 miles north of the mouth of Dewatto Bay. See oblique photo #144348. See Table 23 for the shoreline characteristics of individual driftcells along this reach.

Docks and Piers

A total of four sets of stairs were reported along this shoreline (Hirschi *et al.* 2002). See Table 37.

Stormwater/Wastewater

Residential development along this shoreline is generally confined to small individual homes (Washington Department of Ecology 2000b). Stormwater impacts from these homes are presumed to be minimal. Some of the homes are located close to the shoreline and may contribute wastewater to the Canal, but impacts are likely minimal because of the low development density (TAG 2003).

Landfill

A 0.8 acre salt marsh and 0.1 acre lagoon were historically located on Chinom Point (Point No Point Treaty Council 2003, Unpublished work). The lagoon no longer exists and a portion of the salt marsh is gone (Washington Department of Ecology 2000b). The habitat loss could be the result of filling, or natural vegetative succession (TAG 2003). See oblique photo #152248.

Riparian Buffers

Forestry is the dominant land use in the riparian zone along this shoreline. Riparian buffers on this reach are composed of a mixed forest of coniferous and deciduous trees. Residential development along this stretch of shoreline is sparse (Washington Department of Ecology 2000b).

Tidal Processes

Natural tidal processes appear to be maintained along the entirety of this shoreline (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.

- Restore natural tidal processes and salt marsh habitat at the mouth of the unnamed stream about one mile north of the mouth of Dewatto Bay.

Table 23. Chinom Point to Mouth of Dewatto Bay Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1452	0.6	9,037	8,156	384	384	0	114	Clockwise
1237	0.6	-	-	-	-	-	-	Clockwise
1238	0.6	-	-	-	-	-	-	Clockwise
Totals	0.6	9,037	8,156	384	384	0	114	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Mouth of Dewatto Bay to Bald Point (Driftcells 1239 through 1243)

Shoreline Armoring

Bulkheads were present along 14.9% of this shoreline. The backshore zone consisted of 5,615 meters of high bluff, 1,851 meters of low bluff, 1,288 meters of beaches/spits/berms, 2,537 meters of salt marsh, and 3,915 meters of uplands (Hirschi *et al.* 2002). See Table 24 for the shoreline characteristics of individual driftcells along this reach. A few homes with associated bulkheads are present on the north shore of Dewatto Bay. About 1.7 miles north of Musqueti Point, a small bulkhead prevents sediment recruitment from a bluff. See oblique photo #144944. Bulkheads protect some of the homes on the shoreline from Dewatto Bay south to Rendsland Creek (Washington Department of Ecology 2000b). An artificial spit on the Rendsland Creek delta is protected by riprap (TAG 2003).

Docks and Piers

A total of five docks, two launch ramps, one rail launch, and five sets of stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures in each driftcell along this shoreline. No docks or piers were noted from the mouth of Dewatto Bay south to Rendsland Creek. Small concrete ramps are present to ease access from the landward side of bulkheads down to the beach. Six docks and piers were noted from the lagoon at Rendsland Creek south to Bald Point (Washington Department of Ecology 2000b).

Stormwater/Wastewater

Impervious surfaces on Northshore Road, driveways, and rooftops likely accelerate stormwater runoff and channel pollution to nearby streams and the canal (TAG 2003). However the effects are likely less severe than along the east arm of the canal where residential development is much more prevalent (Washington Department of Ecology 2000b).

Landfill

The head of Dewatto Bay is home to a salt marsh about 14.5 acres in size. Abandoned dikes alter tidal flow over this marsh. Some mudflat habitat was lost to filling at the site of the Oyster House on the south shore of Dewatto Bay (Point No Point Treaty Council 2003, Unpublished work). Much of this fill may have come from the artificial boat basin dredged into the intertidal habitat of Dewatto Bay (Brocksmith 2003, Personal communication). See oblique photo #144654. A small salt marsh is present at the mouth of Little Dewatto Creek (Washington Department of Ecology 2000b). See oblique photo #144810. This salt marsh did not appear on the historic maps (Point No Point Treaty Council 2003, Unpublished work). A 0.9 acre salt marsh and 0.1 acre lagoon were historically present about one mile north of Musqueti Point (Point No Point Treaty Council 2003, Unpublished work). This habitat was lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #145020. Rendsland Creek historically flowed through a left bank channel that is now a man-made lagoon created by building a spit on the delta (Point No Point Treaty Council 2003, Unpublished work). The stream is forced to remain in a straight channel along the spit. Washington Department of Natural Resources purchased the man-made spit from a local landowner. The mouth of the lagoon has been dredged periodically to maintain the channel opening. Aggradation at the mouth of Rendsland Creek causes difficulties for chum fry migrating downstream during low flow conditions (Small 2003, Personal communication). A 3.5 acre salt marsh was historically at the mouth of Rendsland Creek (Northshore Road bisects the location of the historic marsh) (Point No Point Treaty Council 2003, Unpublished work). This salt marsh was lost to filling and residential development (Washington Department of Ecology 2000b). See oblique photo #145114.

Riparian Buffers

Residential land use and transportation are the dominant land uses in the riparian zone. With the exception of a few homes along the shoreline, a continuous buffer of mixed coniferous and deciduous forest is present from the community of Dewatto south to Rendsland Creek (Washington Department of Ecology 2000b). Riparian vegetation is severely limited by residential development and the close proximity of Northshore Road to the shoreline on the south shore of Dewatto Bay and from Rendsland Creek south to Bald Point (Washington Department of Ecology 2000b).

Tidal Processes

An undersized culvert at the mouth of an unnamed stream limits tidal inflow (TAG 2003). See oblique photo #144726. An artificial spit/lagoon complex on the Rendsland Creek delta alters natural tidal flow (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove abandoned dikes on the salt marsh at the head of Dewatto Bay.
- Remove fill and restore lost mudflat habitat at the Oyster House and artificial boat basin on the south shore of Dewatto Bay.

- Remove old pilings in Dewatto Bay, near Red Bluff, and on the Rendsland Creek delta.
- Approach the owner of land about one mile north of Musqueti Point regarding restoration of lost salt marsh and lagoon habitat.
- Remove intertidal fill and shoreline armoring on the spit at the mouth of Rendsland Creek.
- Remove fill and restore salt marsh habitat at the Northshore Road crossing on Rendsland Creek.

Table 24. Mouth of Dewatto Bay to Bald Point Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1239	0.0	337	337	0	0	0	0	Divergence Zone
1240	10.7	459	72	277	0	49	61	Counter-clockwise
1241	9.8	3,394	0	384	0	1,573	1,436	Undefined
1242	14.5	10,640	5,206	1,190	1,288	915	2,041	Clockwise
1243	97.8	377	0	0	0	0	377	Clockwise
Totals	14.9	15,207	5,615	1,851	1,288	2,537	3,915	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Bald Point to Sisters Point (Driftcells 1244 through 1249)

Shoreline Armoring

Bulkheads were present along 45.9% of this shoreline. The backshore zone consisted of 82 meters of low bluffs, 1,092 meters of beaches/spits/berms, 961 meters of salt marsh, and 10,249 meters of uplands (Hirschi *et al.* 2002). Bulkheads and riprap protect the majority of homes and private lots along this stretch of shoreline (Washington Department of Ecology 2000b). Bulkheads and riprap protect homes in the community of Tahuya on the right bank of the Tahuya River estuary near Caldervin Creek. The remainder of the estuary does not have shoreline armoring. Bulkheads are commonplace from the mouth of the Tahuya estuary east to Sisters Point (Washington Department of Ecology 2000b). See Table 25 for the shoreline characteristics of individual driftcells along this reach.

Docks and Piers

Only a few docks and piers are present on this shoreline, but concrete boat ramps are present at many residences (Washington Department of Ecology 2000b). A total of 12 docks, one jetty, 18 launch ramps, and 20 rail launches were reported along this shoreline (Hirschi *et al.* 2002). See Table 37 for the number of man-made structures observed in each driftcell along this reach.

Stormwater/Wastewater

Impervious surfaces on Northshore Road, residential streets in the community of Tahuya, driveways, and rooftops likely accelerate stormwater runoff and channel pollutants to the lower reaches of streams and the canal (TAG 2003).

Landfill

A 4.5 acre salt marsh was historically present on Browns Point (Point No Point Treaty Council 2003, Unpublished work). Most of this salt marsh was lost to filling and home development, but a small portion is still present waterward of bulkheads (Washington Department of Ecology 2000b). See oblique photo #145248. A 0.7 acre salt marsh historically present about 0.7 mile east of Browns Creek (15.0444) was lost to residential development (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #145308. Two small streams are constrained by residential development about one mile east of the mouth of Browns Creek (Washington Department of Ecology 2000b). See oblique photo #145312. A 2.7 acre salt marsh was historically present about 0.2 miles west of the mouth of Caldervin Creek (15.0445). A large mudflat, salt marsh, and accretion spit complex was historically present on the right bank of the mouth of Caldervin Creek (Point No Point Treaty Council 2003, Unpublished work). All of these habitats were lost to filling and dense residential development (Washington Department of Ecology 2000b). See oblique photos #145342 and #145406. According to historic maps, approximately 26.5 acres of salt marsh were present in the Tahuya River estuary. Only 0.5 acres have been lost to residential development (Point No Point Treaty Council 2003, Unpublished work). As of 1994, salt marsh habitat had expanded to cover approximately 33 acres (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2003). These salt marshes are very productive juvenile salmonid feeding areas (Boad 2003, Personal communication). See oblique photo #145508.

Riparian Buffers

Residential land use is the dominant land use within the riparian zone along this stretch of shoreline. Riparian buffer width and extent are severely limited by shoreline residences and the close proximity of Northshore Road to the canal from Bald Point east to the Tahuya estuary (Washington Department of Ecology 2000b). Both sides of the Tahuya River estuary have substantial riparian buffers dominated by mature coniferous trees. Riparian buffers are relatively narrow and sparse from the mouth of the Tahuya River east to Sisters Point (Washington Department of Ecology 2000b).

Tidal Processes

The narrow opening under the Northshore Road crossing on the Tahuya River may restrict tidal flow, but this has not been evaluated (TAG 2003). Tidal influence upstream of the current road crossing is sufficient to completely inundate the salt marshes above the crossing (Boad 2003, Personal communication). Dense residential development constricts the mouths of most streams along this stretch of shoreline, altering both tidal and fluvial processes. Disruption of these processes alters sedimentation patterns in the nearshore (Brocksmith 2003, Personal communication).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove intertidal fill in the vicinity of Caldervin Creek and restore lost mudflat and salt marsh habitats.
- Remove the helicopter landing pad on the left bank of the Tahuya River downstream from Northshore Road.
- Evaluate the bridge span at the Northshore Road crossing of the Tahuya River for impaired tidal circulation and if necessary, construct a longer span to improve tidal flow.
- Store floating docks on upland areas during the winter months, rather than stockpiling along the right bank of the Tahuya downstream from Northshore Road.

Table 25. Bald Point to Sisters Point Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1244	42.8	870	0	0	0	0	870	Divergence Zone
1245	54.5	4,379	0	0	847	610	2,923	Counter-clockwise
1246	1.0	3,900	0	0	148	351	3,402	Undefined
1247	71.0	612	0	82	97	0	434	Clockwise
1248	100.0	461	0	0	0	0	461	Divergence Zone
1249	82.7	2,159	0	0	0	0	2,159	Counter-clockwise
Totals	45.9	12,381	0	82	1,092	961	10,249	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Sisters Point to Northshore Gravel Pit (Driftcells 1250 through 1257)

Shoreline Armoring

With the exception of areas where Northshore Road is directly adjacent to the canal, this shoreline is heavily developed with residences. Most homes and property are protected by bulkheads (Washington Department of Ecology 2000b). Bulkheads were present along 62.9% of this shoreline. The backshore zone consisted of 615 meters of beaches/spits/berms, 343 meters of salt marsh, and 5,730 meters of uplands (Hirschi *et al.* 2002). See Table 26 for the shoreline characteristics of individual driftcells along this reach.

Docks and Piers

Small floating docks, rail launches, and concrete boat ramps are present at many properties on this reach (Washington Department of Ecology 2000b). A total of 10 docks, one launch ramp, and one rail launch were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell along this shoreline.

Stormwater/Wastewater

Impervious surfaces on Northshore Road, driveways, and rooftops likely accelerate stormwater runoff and channel pollution to lower stream reaches and the canal (TAG 2003).

Landfill

About 0.06 acre of a 0.2 acre salt marsh remains approximately one mile east of Sisters Point. The majority of the salt marsh was lost to fill and home development (Washington Department of Ecology 2000b, Point No Point Treaty Council 2003, Unpublished work). See oblique photo #145816. A historic salt marsh located immediately west of the mouth of Shoofly Creek was lost to filling and home development (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #145950. A 1.0 acre salt marsh and two spits were historically located about 0.07 miles east of the mouth of Shoofly Creek (Point No Point Treaty Council 2003, Unpublished work). These habitat features were lost to residential development (Washington Department of Ecology 2000b). See oblique photo #150006. The mouth of Little Shoofly Creek (15.0483) is constrained by fill and residential development. See oblique photo #150026. A 1.1 acre salt marsh was historically located on the west side of the artificial spit at the Northshore gravel pit (Point No Point Treaty Council 2003, Unpublished work). This salt marsh was lost to residential development (Washington Department of Ecology 2000b).

Riparian Buffers

Riparian buffers are limited in width and extent by residential development and the close proximity of Northshore Road to the shoreline (Washington Department of Ecology 2000b).

Tidal Processes

Dense residential development constricts the mouths of most streams along this stretch of shoreline (Washington Department of Ecology 2000b), altering both tidal and fluvial processes. Disruption of these processes alters sedimentation patterns in the nearshore (Brocksmith 2003, Personal communication).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.

Table 26. Sisters Point to North Shore Gravel Pit Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1250	0.0	311	0	0	133	0	178	Clockwise
1251	39.8	514	0	0	0	0	514	Divergence Zone
1252	71.0	513	0	0	236	0	277	Counter-clockwise
1253	79.8	354	0	0	20	0	334	Clockwise
1254	84.8	703	0	0	0	0	703	Divergence Zone
1255	57.1	2,491	0	0	0	287	2,204	Counter-clockwise
1256	100.0	329	0	0	0	11	318	Clockwise
1257	69.0	1,472	0	0	226	45	1,202	Counter-clockwise
Totals	62.9	6,687	0	0	615	343	5,730	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Northshore Gravel Pit to Sunbeach (Driftcells 1258 through 1262)

Shoreline Armoring

Residential development is relatively intense along this entire shoreline. Most homes are protected by bulkheads or riprap (Washington Department of Ecology 2000b). Bulkheads were present along 62.7% of this shoreline. The backshore zone consisted of 228 meters of beaches/spits/berms, 3,083 meters of salt marsh, and 4,475 meters of uplands (Hirschi *et al.* 2002). See Table 27 for the shoreline characteristics of individual driftcells along this reach. The mouth of "Johnson Creek" (15.0492) is constrained by bank armoring (Washington Department of Ecology 2000b).

Docks and Piers

Docks and piers are much less common on this shoreline than on the south shore. However, there are large numbers of private concrete boat ramps (Washington Department of Ecology 2000b). A total of six docks, seven jetties, nine launch ramps, and one rail launch were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell along this shoreline.

Stormwater/Wastewater

Impervious surfaces on Northshore Road, driveways, and rooftops likely accelerate stormwater runoff and channel pollutants into the lower reaches of streams and the canal (TAG 2003).

Landfill

The spit adjacent to the Northshore Gravel Pit was created from gravel mined from the pit (Boad 2003, Personal communication). A 0.6 acre salt marsh was historically present just east of the mouth of unnamed stream 15.0485 (Point No Point Treaty Council 2003, Unpublished work). The salt marsh was lost to residential development (Washington Department of Ecology 2000b). See oblique photo #15.0056.

A 0.73 acre salt marsh 0.05 miles west of Cady Creek was lost to fill and home development (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150116. Cady Creek is heavily constrained by residential development downstream from Northshore Road (Washington Department of Ecology 2000b). See oblique photo #150120. About 1.3 acres of salt marsh were lost to filling and home development about 0.1 miles west of "Hall Creek" (Point No Point Treaty Council 2003, Unpublished work). "Hall Creek," about 0.15 miles west of "Northshore Nursery Creek" is constrained by residential development from Northshore Road downstream (Washington Department of Ecology 2000b). See oblique photo #150138. A 0.2 acre salt marsh was historically located about 0.1 miles east of "Northshore Nursery Creek" (15.0487) (Point No Point Treaty Council 2003, Unpublished work). This salt marsh was lost to filling and home development (Washington Department of Ecology 2000b). A 6.4 acre salt marsh just east of "Johnson Creek" was lost to filling and residential development (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150250.

Riparian Buffers

Riparian buffers along this shoreline are severely limited by residential development and the close proximity of Northshore Road to the canal. A limited number of undeveloped properties with significant stands of mature coniferous forest are present on this stretch of shoreline (Washington Department of Ecology 2000b).

Tidal Processes

No dikes were noted along this stretch of shoreline (Washington Department of Ecology 2000b), but constraining the lower reaches of streams impairs tidal processes, creating aggrading deltas and restricting channel meandering (Small 2003, Personal communication).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.

Table 27. Northshore Gravel Pit to Sunbeach Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1258	72.9	309	0	0	228	0	81	Clockwise
1259	42.2	483	0	0	0	0	483	Divergence Zone
1260	69.8	4,907	0	0	0	1,275	3,633	Counter-clockwise
1261	58.8	1,268	0	0	0	989	278	Clockwise
1262	32.9	819	0	0	0	819	0	Divergence Zone
Totals	62.7	7,786	0	0	228	3,083	4,475	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Sunbeach to Devereaux Creek Spit (Driftcells 1263 and 1264)

<u>Shoreline Armoring</u>

Bulkheads are commonly associated with pockets of shoreline residential development from Sunbeach east to Lynch Cove Community Park. The shoreline at Belfair State Park near the mouth of Big Mission Creek has been armored with riprap (Washington Department of Ecology 2000b). See oblique photo #150324. A small concrete pool at Lynch Cove Community Park serves as shoreline armor, altering the natural beach profile (Washington Department of Ecology 2000b). Almost no shoreline armoring is present from the Klingel Wetlands to the spit at Devereaux Creek (Washington Department of Ecology 2000b). Bulkheads were present along 1.8% of this shoreline. The backshore zone consisted of 8,964 meters of salt marsh, and 665 meters of uplands (Hirschi *et al.* 2002). See Table 28 for the shoreline characteristics of individual driftcells along this reach.

<u>Docks and Piers</u>

Very few docks and piers are present on this shoreline (Washington Department of Ecology 2000b). A total of one launch ramp was reported by Hirschi *et al.* (2002).

<u>Stormwater/Wastewater</u>

Impervious surfaces on SR 300, residential streets, driveways, and rooftops likely accelerate stormwater runoff and channel pollution into nearby streams and the canal (TAG 2003).

<u>Landfill</u>

Residential development west of Boad Haven Road covered 2.7 acres of salt marsh habitat. See oblique photo #150328. Filling and residential development at Cherokee Beach Road destroyed 6.5 acres of a 12.6 acre salt marsh (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150344. Approximately 8 acres of salt marsh were lost to filling at the west end of Belfair State Park. An additional 2.3 acres of salt marsh were lost to filling on the east end of the park. See oblique photo #150410. About 1.75 acres of salt marsh were lost to filling at the site of Snooze Junction (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150422. About one acre of salt marsh was lost to filling and home development immediately west of Lynch Cove Community Park (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #150426. Ninety-three acres of salt marsh were historically present from Lynch Cove Community Park to the right bank of the mouth of the Union River (Point No Point Treaty Council 2003, Unpublished work). Salt marsh is still present in the Klingel Wetlands, but tidal access is regulated by dikes and tide gates (Washington Department of Ecology 2000b). See oblique photo #150456. About 6.5 acres of the 93 acre salt marsh have been lost to filling and residential development to the east of the Klingel Wetlands (Washington Department of Ecology 2000b). See oblique photo #150504. A wetland northwest of the intersection of SR 300 and Sand Hill Road is heavily used by rearing juvenile salmonids. The wetland was historically connected to Lynch Cove, but today the outlet drains through a ditch along North Shore Road (TAG 2003). See oblique photo #150534. A 107 acre salt marsh stretches from the spit at the mouth of Devereaux Creek across the head of Lynch Cove to the mouth of the Union River. This salt marsh is in a relatively natural condition (Washington Department of Ecology 2000b). The area was diked historically to farm the salt marsh, but with the exception of the farm at the mouth of the Union River, the dikes are no longer functional. It has not been determined if the deteriorating borrow ditches and remnant dikes are adversely affecting habitat function (TAG 2003). See oblique photos #151120-150738.

Riparian Buffers

Riparian buffers are limited by residential development from Sunbeach east to Big Mission Creek. However, some large patches of forest are interspersed within the development (Washington Department of Ecology 2000b). From Big Mission Creek east to the Klingel Wetlands pockets of residential development along the shoreline limit the extent of riparian buffers (Washington Department of Ecology 2000b). From the Klingel Wetlands east to the Union River, SR 300 is generally relatively isolated from the canal by salt marshes and small patches of riparian forest (Washington Department of Ecology 2000b). The majority of the shoreline from Devereaux Creek to the farm on the left bank of the mouth of the Union River is covered with mixed stands of coniferous and deciduous trees and high quality salt marshes (Washington Department of Ecology 2000b).

Tidal Processes

A dike was installed at Belfair State Park to create a wading pool. This dike disrupts tidal function and constrains the mouth of Big Mission Creek (Washington Department of Ecology 2000b). See oblique photo #150410. An apparently abandoned private road east of Snooze Junction appears to restrict tidal flow to the salt marsh west of the road. See oblique photo #150422. Natural tidal processes appear to be maintained in Lynch Cove with the exception of diked areas at the Klingel Wetlands and the farm at the mouth of the Union River. Although salt marshes at the Theler Wetlands were historically diked and ditched, lack of maintenance has caused deterioration of the infrastructure, allowing the salt marshes to begin to return to a natural state (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove levees, young alders, and aggraded delta cone on Little Mission Creek to allow more natural sediment routing in estuary.
- Remove fill at Belfair State Park and restore lost salt marsh habitat.
- Remove the dike and tide gates at Belfair State Park.
- Restore forested riparian buffers at Belfair State Park.
- Remove fill at Snooze Junction and restore lost salt marsh habitat.
- Remove the private road east of Snooze Junction to restore tidal access to salt marsh west of the road.
- Remove the small concrete pool, boat ramp, fill, and bulkhead at Lynch Cove Community Park to restore lost salt marsh.

- Remove dikes and tide gates at the Klingel Wetlands and fill dike borrow pits.
- Remove fill, pool, and infrastructure to the east of the Klingel Wetlands and restore lost salt marsh habitat.
- Restore salt marsh habitat at the farm on the east bank of the mouth of the Union River
- Monitor borrow ditches and remnant dikes on the salt marsh of Lynch Cove to ensure natural formation of dendritic tidal channels.

Table 28. Sunbeach to Devereaux Creek Spit Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1263	1.8	9,629	0	0	0	8,964	665	No appreciable net shore drift
1264	1.8	-	-	-	-	-	-	No appreciable net shore drift
Totals	1.8	9,629	0	0	0	8,964	665	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Devereaux Creek Spit to Sunset Beach (Driftcells 1265 through 1267)

Shoreline Armoring

The majority of this shoreline (70.9%) is armored with bulkheads or riprap. The backshore zone consisted of 77 meters of beaches/spits/berms, 1,264 meters of salt marsh, and 3,071 meters of uplands (Hirschi *et al.* 2002). See Table 29 for the shoreline characteristics of individual driftcells along this reach. Small salt marshes have formed waterward of bulkheads at several locations (Washington Department of Ecology 2000b).

Docks and Piers

Private docks and piers are much less common along this stretch of shoreline than the reaches to the west (Washington Department of Ecology 2000b). This is likely a result of the shallow water depth of this portion of the canal. A total of 17 docks and three launch ramps were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell.

Stormwater/Wastewater

Impervious surfaces on SR 106 likely accelerate stormwater runoff and channel pollutants to the canal and streams along this shoreline (TAG 2003). However, there is a great deal more mature coniferous riparian forest buffer along this shoreline than the shorelines to the west (Washington Department of Ecology 2000b).

Landfill

A 0.68 acre salt marsh was historically present adjacent to unnamed stream 14.0125 (Point No Point Treaty Council 2003, Unpublished work). This salt marsh was lost to filling and home development (Washington Department of Ecology 2000b). See oblique photo #151410. The lower portion of Lakewood Creek (14.0126) appears to be constrained by road fill under SR 106 and armoring on the left bank downstream from the highway (Washington Department of Ecology 2000b). See oblique photo #151512.

Riparian Buffers

Residential land use is the dominant land use within the riparian corridor. Numerous undeveloped lots are present along this shoreline. Patches of mature coniferous forest are scattered throughout the area. Riparian forests are particularly lush near the mouth of Devereaux Creek (Washington Department of Ecology 2000b).

Tidal Processes

Fill and bulkheads adjacent to the mouth of Lakewood Creek have constrained the subestuary (Washington Department of Ecology 2000b).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Restore the natural estuary of Lakewood Creek (Springbrook Creek) and install a bridge at SR 106 to allow tidal influence upstream.

Table 29. Devereaux Creek Spit to Sunset Beach Nearshore Habitat Characteristics.

		Length (meters)						
Driftcell[a] ID	% Bulkhead[b]	Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1265	67.5	3,520	0	0	0	1,264	2,256	Clockwise
1266	100.0	459	0	0	0	0	459	Divergence Zone
1267	71.0	433	0	0	77	0	356	Counter-clockwise
Totals	70.9	4,412	0	0	77	1,264	3,071	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Sunset Beach to Twanoh State Park (Driftcells 1268 through 1270)

Shoreline Armoring

Bulkheads were present along 73.4% of this shoreline. The backshore zone consisted of 321 meters of beaches/spits/berms, 13 meters of salt marsh, and 7,743 meters of uplands (Hirschi *et al.* 2002). See Table 30 for the shoreline characteristics of individual driftcells along this reach. A community beach and homes placed on fill east of the mouth of Twanoh Falls Creek are protected by bulkheads (Washington Department of Ecology 2000b, TAG 2003). See oblique photo #151724.

Docks and Piers

A total of 42 docks, eight launch ramps, two rail launches, and one set of stairs were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell along this shoreline.

Stormwater/Wastewater

Impervious surfaces on SR 106 likely accelerate stormwater runoff and channel pollutants into the canal (TAG 2003).

Landfill

The mouth of Holyoke Creek is constrained by a culvert and road fill (Washington Department of Ecology 2000b, TAG 2003). A 1.3 acre salt marsh was historically present about 0.4 miles east of the mouth of "Mulberg Creek." This marsh was lost to filling and development. A large amount of intertidal fill has been placed on both sides of Twanoh Falls Creek (14.0132) downstream from SR 106 (Point No Point Treaty Council 2003, Unpublished work). This fill has channelized the stream and significantly reduced the size of the subestuary (TAG 2003). See oblique photo #151724.

Riparian Buffers

Riparian buffer width and vegetation presence along this entire reach are severely limited by shoreline home developments and SR 106. Bulkheads and lawns dominate the shoreline (Washington Department of Ecology 2000b).

Tidal Processes

Tidal inflow to "Happy Hollow Creek" (14.0129) appears to be impeded by the SR 106 crossing. See oblique photo #151628. The size of the Twanoh Falls Creek subestuary has been substantially reduced by intertidal filling (TAG 2003).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Restore tidal function at the mouth of Holyoke Creek by installing a bridge.
- Restore tidal processes and anadromous fish access to "Rearing Pond Creek" (about 0.17 miles east of stream #14.0130) by removing barriers.
- Remove intertidal fill at the mouth of Twanoh Falls Creek, recreate natural channel geometry and tidal functions.

Table 30. Sunset Beach to Twanoh State Park Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1268	78.9	6,993	0	0	139	13	6,841	Clockwise
1269	49.6	411	0	0	0	0	411	Divergence Zone
1270	26.9	673	0	0	182	0	491	Counter-clockwise
Totals	73.4	8,077	0	0	321	13	7,743	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

Twanoh State Park to Union (Driftcells 1271 through 1274)

Shoreline Armoring

Bulkheads have destroyed forage fish habitat and altered the natural beach profile along much of this shoreline (Washington Department of Ecology 2000b, TAG 2003). Hirschi *et al.* (2002) identified bulkheads along 67.7% of this shoreline. The backshore zone consisted of 29 meters of beaches/spits/berms, and 13,618 meters of uplands (Hirschi *et al.* 2002). See Table 31 for the shoreline characteristics of individual driftcells along this reach. The shoreline adjacent to two parking lots at Twanoh State Park is armored with riprap (Washington Department of Ecology 2000b). See oblique photo #151812. The beach at Twanoh State Park is heavily used by spawning surf smelt (Small 2003, Personal communication).

Docks and Piers

Grounded piers and docks along this stretch of shoreline disrupt migration of juvenile salmonids by forcing migrating fish to move into deeper water where they are more vulnerable to predators. Floating dock ends reduce primary production in the intertidal zone (Washington Department of Ecology 2000b, TAG 2003). A total of 96 docks, one jetty, three launch ramps, and one rail launch were reported by Hirschi *et al.* (2002). See Table 37 for the number of man-made structures observed in each driftcell along this shoreline.

Stormwater/Wastewater

Impervious surfaces on SR 106 and parking lots at Twanoh State Park and Alderbrook Inn likely accelerate stormwater runoff and channel pollutants such as antifreeze and oil into the lower portions of streams and Hood Canal (TAG 2003).

Landfill

About 3.6 acres of historic salt marsh were lost to filling at the site of Twanoh State Park (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #151812. Historically a small lagoon, spit, and 0.17 acre salt marsh were present at “Morang Point” (Point No Point Treaty Council 2003, Unpublished work). These features were lost to filling and home development. See oblique photo #151842. A salt marsh about 1.0 acre in size was historically located about 0.5 mile east of "Burn salt marsh" (Point No Point Treaty Council 2003, Unpublished work). This salt marsh was lost to filling and residential development. See oblique photo #152018. "Burn salt marsh," 1.8 acres in size was lost to filling and home construction (Point No Point Treaty Council 2003, Unpublished work). This salt marsh was located on the south shore directly across from Sisters Point. See oblique photo #152036. A portion of "Nordstrom Creek" is buried under a tennis court. The landowner(s) would like to restore the natural channel geometry of the buried portion of stream (Boad 2003, Personal communication). The mouth of Alderbrook Creek is constricted by fill placed at the Alderbrook Inn (Washington Department of Ecology 2000b, TAG 2003). A historic accretion spit and salt marsh complex have been lost to filling at the site of Union Marina (Point No Point Treaty Council 2003, Unpublished work). See oblique photo #152400.

Riparian Buffers

Riparian buffer width along the majority of this shoreline is limited by the close proximity of SR 106 and homes to the shoreline (Washington Department of Ecology 2000b, TAG 2003).

Tidal Processes

Fill for home construction, SR 106, and other uses has reduced the historic extent of intertidal wetlands (Point No Point Treaty Council 2003, Unpublished work) and impeded tidal circulation at the mouths of some streams (TAG 2003). A culvert and road fill at "Big Bend Creek" likely limit tidal exchange at the creek mouth (Washington Department of Ecology 2000b, TAG 2003).

Non-Prioritized Action Recommendations

- See "General Nearshore Recommendations."
- See Table 33 for prioritized nearshore action recommendations.
- Remove fill and riprap at Twanoh State Park, restore salt marsh and intertidal habitat, and remove concrete wall and culvert at wading pool.
- When replacement is necessary, convert the Twanoh State Park boat ramp to an elevated design to allow transport of sediment and enhance juvenile salmonid migration.
- Remove bulkhead along Alderbrook Creek estuary and restore the historic inlet.
- Restore riparian vegetation along Alderbrook Creek below SR 106.
- Evaluate tidal exchange at the mouth of Big Bend Creek and replace culvert with a bridge if natural processes are hindered by the culvert and road fill.
- Remove derelict barge at the mouth of Big Bend Creek.
- Remove creosoted pilings at Union Marina.

Table 31. Twanoh State Park to Union Nearshore Habitat Characteristics.

Driftcell[a] ID	% Bulkhead[b]	Length (meters) Driftcell Total[b]	High Bluff[b]	Low Bluff[b]	Beaches –Spits – Berms[b]	Salt marsh[b]	Upland[b]	Drift Direction[a]
1271	70.3	8,439	0	0	29	0	8,410	Clockwise
1272	90.1	457	0	0	0	0	457	Divergence Zone
1273	27.9	353	0	0	0	0	353	Counter-clockwise
1274	63.8	4,398	0	0	0	0	4,398	Clockwise
Totals	67.7	13,647	0	0	29	0	13,618	

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). Note: See Maps 8 & 9 for locations of driftcells. See Appendix D to cross-reference driftcell IDs with driftcell names used in Hirschi *et al.* (2002).

PRIORITIZED NEARSHORE ACTION RECOMMENDATIONS

Prioritization Method

The criteria below, published in Correa (2002), were used to prioritize nearshore action recommendations.

Proximity to priority watersheds, maximum 5 points

The proximity to priority watersheds, as determined by the Hood Canal Coordinating Council's salmon habitat recovery strategy (Hood Canal Coordinating Council 2002), was evaluated as follows:

- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 1 estuary, the action received the maximum of 5 points.
- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 2 estuary, the action received 4 points.
- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 3 estuary, the action received 3 points.
- The value was reduced by one point if the action was between 1.0 and 7.0 miles from a Tier 1, 2, or 3 estuary.
- The value was reduced by two points if the action was greater than 7.0 miles from a Tier 1, 2, or 3 estuary.

Spatial Scale, maximum 5 points

The size of the benefit was evaluated as follows:

- The action received the maximum of 5 points if the project protected and/or restored greater than 10 acres of habitat.
- The action received 4 points if the action protected and/or restored 5 to 10 acres of habitat.
- The action received 3 points if the action protected and/or restored 2 to 5 acres of habitat.
- The action received 2 points if the project protected and/or restored ½ to 2 acres of habitat.
- The action received one point if the project protected and/or restored less than ½ acre of habitat.

Ecological Scale, maximum 5 points

Ecological scale was designed to evaluate impacts to nearshore processes. If the action addressed multiple processes, species and life histories, it received a higher value. For example, if an action recommendation involved estuary restoration that would affect both nearshore and riverine processes, such as dike removal in the lower floodplain, it received a higher score than one that involved a single process, such as the removal of individual creosoted pilings, which systematically received one point.

Temporal Scale, maximum 3 points

Temporal scale was designed to evaluate the longevity of a benefit(s) gained through implementation of a recommendation. For example, if the action recommendation restored a nearshore process that provided long-term benefits, it received a higher score than a project that provided short-term benefits and required considerable maintenance.

Nearshore stressors and corresponding impacts to habitat conditions and juvenile salmonids are summarized in Table 32.

Table 32. Nearshore Stressor-Effects, from (Correa 2002).

Causal Factors/ Stressors	Physical Processes Altered	Physical/Chemical Effects	Habitat Effects	Juvenile Salmon Effects
Shoreline Armoring (riprap, bulkheads)	a. erosion/sediment transport (backshore, intertidal and alongshore)	a. altered beach sediment size/type b. decreased sediment abundance c. increased wave energy d. water quality declines from flow alteration, accumulation of drift material (including macroalgae blooms)	a. altered plant/animal assemblages (loss of eelgrass/copepods) b. beach scouring and/or lowering c. loss of shallow nearshore d. loss of connectivity e. altered shoreline hydrodynamics/drift (groins, etc.)	a. reduced prey b. increased predation c. altered migration
Overwater Structures (stairs, docks, marinas)	a. erosion/sediment transport	a. altered beach sediment size/type b. decreased sediment abundance c. light limitation/alteration d. water quality declines from flow alteration, accumulation of drift material (including macroalgae blooms)	a. altered plant/animal assemblages b. altered access to shallow nearshore corridor	a. reduced prey b. increased predation c. altered migration
Ramps	a. erosion/sediment transport	a. altered beach sediment type/size b. altered sediment distribution	a. altered plant/animal assemblages	a. reduced prey
Stormwater Wastewater	a. nutrient input b. freshwater input	a. low dissolved oxygen b. contaminant loading c. nutrient loading d. physical scouring from increased runoff e. increased shoreline erosion from poor stormwater conveyance/maintenance f. alteration of beach hydrodynamics	a. altered plant/animal assemblages (including macroalgae blooms) b. lost habitat due to eelgrass declines from smothering, anoxia, shading, etc. c. forcing of habitat shifts due to blooms (slowing of water, accumulation of nutrients, etc.)	a. increased injury risk (lesions, tumors) b. reduced prey c. reduced habitat
Landfill (below the high water line)	a. tidal exchange b. erosion/sediment transport	a. delta and lagoon loss b. altered beach sediment size/type c. decreased sediment abundance d. increased wave energy	a. altered plant/animal assemblages b. loss of shallow nearshore corridor c. loss of riparian d. beach scouring and/or lowering e. loss of connectivity	a. reduced prey b. osmoregulation (due to delta/lagoon loss) c. increased predation
Riparian Buffers	a. nutrient input b. erosion/sediment transport c. large wood function in spit formation	a. increased temperature b. organic input (food web)	a. shade b. erosion c. LWD function	a. reduced prey b. increased predation

Table 33. Prioritized Nearshore Action Recommendations.

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
2	Foulweather Bluff to Point Julia	Assess geomorphic history of Foulweather Nature Conservancy marsh and improve functions.	1	NR	NR	NR	NR	142816
3	Foulweather Bluff to Point Julia	Explore options to restore lost riparian, salt marsh, lagoon, and intertidal habitat at Driftwood Key (Coon Bay).	1	NR	NR	NR	NR	143010-143110
32	Warrenville Mudflat to Misery Point	Remove road fill and structures on historic spit feature at Seabeck to restore sediment and tidal processes.	4	5	5	3	17	145628
48	Mouth of Dewatto Bay to Bald Point	Remove abandoned dikes on the salt marsh at the head of Dewatto Bay.	4	5	5	3	17	144654
54	Bald Point to Sisters Point	Remove intertidal fill in the vicinity of Caldervin Creek and restore lost mudflat and salt marsh habitats.	4	5	5	3	17	145342 145406
61	Sunbeach to Devereaux Creek Spit	Remove the dike and tide gates at Belfair State Park.	4	5	5	3	17	150410
68	Sunbeach to Devereaux Creek Spit	Restore salt marsh habitat at the farm on the east bank of the mouth of the Union River.	4	5	5	3	17	151120
69	Sunbeach to Devereaux Creek Spit	Monitor borrow ditches and remnant dikes on the salt marsh of Lynch Cove to ensure natural formation of dendritic tidal channels.	4	5	5	3	17	150732

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
31	Teekalet Bluff to Warrenville Mudflat	Restore natural tidal influence and sediment transport in the Big Beef Creek subestuary.	4	5	5	2	16	145346
38	Hood Point to Anderson Cove	Remove log retention structures in the tidal channels on the Boyce Creek delta and convert derelict beach house to an interpretive center or remove.	4	4	5	3	16	150856
57	Bald Point to Sisters Point	Evaluate the bridge span at the Northshore Road crossing of the Tahuya River for impaired tidal circulation and if necessary, construct a longer span to improve tidal flow.	4	5	5	2	16	145414a
60	Sunbeach to Devereaux Creek Spit	Remove fill at Belfair State Park and restore lost salt marsh habitat.	4	5	4	3	16	150410
75	Twanoh State Park to Union	Remove fill and riprap at Twanoh State Park, restore salt marsh and intertidal habitat, and remove concrete wall and culvert at wading pool.	3	5	5	3	16	151812
33	Warrenville Mudflat to Misery Point	Restore intertidal wetlands and salt marsh at Nick's Lagoon by removing log structures and associated fill; remove derelict boats and other refuse.	4	3	5	3	15	150048
34	Misery Point to Hood Point	Acquire property south of WDFW Misery Point boat launch at Miami Beach to restore lost salt marsh, spit, and lagoon habitats. Restore sediment supply.	4	4	4	3	15	150222
42	Anderson Cove to Chinom Point	Remove old railroad grade and pilings from the head of Anderson Cove. Assess impacts to Holly Road.	4	3	5	3	15	151622

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
49	Mouth of Dewatto Bay to Bald Point	Remove fill and restore lost mudflat habitat at the Oyster House and artificial boat basin on the south shore of Dewatto Bay.	4	3	5	3	15	144654
52	Mouth of Dewatto Bay to Bald Point	Remove intertidal fill and shoreline armoring on spit at the mouth of Rendsland Creek.	4	3	5	3	15	145114
53	Mouth of Dewatto Bay to Bald Point	Remove fill and restore salt marsh habitat at the Northshore Road crossing on Rendsland Creek.	4	3	5	3	15	145114
66	Sunbeach to Devereaux Creek Spit	Remove dikes and tide gates at the Klingel Wetlands and fill dike borrow pits.	4	4	4	3	15	150456
25	Teekalet Bluff to Warrenville Mudflat	Remove road and fill to restore accretion spits and intertidal lagoon at Devil's Hole Creek.	2	5	5	2	14	144828
30	Teekalet Bluff to Warrenville Mudflat	Restore tidal processes, and lost salt marsh habitat at the mouth of Johnson Creek.	4	2	5	3	14	145216
59	Sunbeach to Devereaux Creek Spit	Remove levees, young alders, and aggraded delta cone on Little Mission Creek to allow more natural sediment routing in estuary.	4	3	4	3	14	150356
63	Sunbeach to Devereaux Creek Spit	Remove fill at Snooze Junction and restore lost salt marsh habitat.	4	2	5	3	14	150414

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
8	Foulweather Bluff to Point Julia	Evaluate effects of Hood Canal Floating Bridge on wave energy/sediment transport north of the bridge, and redesign bridge or its operations as needed.	1	5	5	2	13	NA
15	Point Julia to Teekalet	Remove intertidal fill, armoring, log storage debris, and pilings at the Port Gamble Log Mill to restore intertidal habitat.	1	5	4	3	13	144032
16	Point Julia to Teekalet	Remove intertidal fill and armoring of jetty/breakwater to restore sediment processes at Port Gamble Point. Restore riparian zone.	1	5	4	3	13	144108 144112
21	Teekalet Bluff to Warrenville Mudflat	Restore salt marsh and lagoon habitat; restore fish passage at the mouth of Cattail Creek.	1	5	5	2	13	144648
23	Teekalet Bluff to Warrenville Mudflat	Minimize impacts to the photic zone and the juvenile salmonid migratory corridor by over water structures on the Bangor Naval Station.	2	5	4	2	13	NA
29	Warrenville Mudflat to Misery Point	Remove roads in the Little Anderson Creek Subestuary.	4	1	5	3	13	145152
39	Hood Point to Anderson Cove	Remove wooden seawall and restore natural channel geometry at mouth of unnamed/unnumbered stream about 0.5 miles south of Boyce Creek.	4	2	4	3	13	150910
45	Anderson Cove to Chinom Point	Restore historic salt marsh and lagoon habitats at the community of Holly.	4	3	3	3	13	151644

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
46	Anderson Cove to Chinom Point	Protect the remaining salt marsh habitat on Chinom Point. Approach the landowner regarding restoration of lost salt marsh habitat, natural intertidal function, and natural channel morphology of the small stream on the north side of the point.	4	2	4	3	13	152248
64	Sunbeach to Devereaux Creek Spit	Remove the private road east of Snooze Junction to restore tidal access to salt marsh west of the road.	4	2	4	3	13	150422
19	Teekalet Bluff to Warrenville Mudflat	Remove creosote bulkhead to restore sediment recruitment and riparian processes along ~1000 ft of shoreline at Kitsap Memorial State Park.	1	4	4	3	12	144408
35	Misery Point to Hood Point	Remove concrete foundations at base of bluff north of unnamed stream at Scenic Beach State Park and revegetate cleared riparian area with native plants.	4	2	3	3	12	150242
36	Misery Point to Hood Point	Remove intertidal fill at mouth of small lagoon between Spear-Fir Lagoon and Stavis Bay and restore sediment processes.	4	1	4	3	12	150350
40	Hood Point to Anderson Cove	Acquire property 1.5 miles south of Boyce Creek and remove riprap to allow sediment recruitment from adjacent bluff; remove home landward out of the intertidal zone.	4	2	3	3	12	151424
44	Anderson Cove to Chinom Point	Remove the county road along the north shore of Anderson Cove (traffic could be rerouted to the road immediately to the north) and revegetate the riparian zone with native plants.	4	2	3	3	12	151622

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
47	Chinom Point to mouth of Dewatto Bay	Restore tidal processes and salt marsh habitat at the unnamed stream about one mile north of the mouth of Dewatto Bay.	4	1	4	3	12	144332
51	Mouth of Dewatto Bay to Bald Point	Approach the owner of land about one mile north of Musqueti Point regarding restoration of lost salt marsh and lagoon habitat.	4	2	3	3	12	145020
55	Bald Point to Sisters Point	Remove the helicopter landing pad on the left bank of the Tahuya River downstream from Northshore Road.	4	1	4	3	12	145550
56	Bald Point to Sisters Point	Remove log structures in old log yard on western end of Tahuya bridge.	4	2	3	3	12	145414a
62	Sunbeach to Devereaux Creek Spit	Restore forested riparian buffers at Belfair State Park.	4	3	3	2	12	150410
67	Sunbeach to Devereaux Creek Spit	Remove fill, pool, and infrastructure to the east of the Klingel Wetlands and restore lost salt marsh habitat.	4	2	3	3	12	150500
4	Foulweather Bluff to Point Julia	Restore tidal influence, salt marsh, and spit habitats at Hawks Hole Creek.	1	3	4	3	11	143238
17	Teekalet Bluff to Warrenville Mudflat	Remove east boat ramp at Kitsap County Park on Salsbury Point, revegetate riparian zone with native plants.	1	4	3	3	11	144148
24	Teekalet Bluff to Warrenville Mudflat	Minimize stormwater impacts from impervious surfaces on Bangor Naval Station.	2	5	2	2	11	NA

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
28	Teekalet Bluff to Warrenville Mudflat	Restore lost salt marsh habitat about 100 meters northeast of the Little Anderson Creek salt marsh.	4	1	3	3	11	145148
37	Hood Point to Anderson Cove	Remove groins south of Hood Point.	4	1	3	3	11	150816
41	Hood Point to Anderson Cove	Remove the abandoned home near the mouth of Harding Creek.	4	1	3	3	11	151440
58	Bald Point to Sisters Point	Store floating docks on upland areas during the winter months, rather than stockpiling along the right bank of the Tahuya downstream from Northshore Road.	4	2	2	3	11	145414a
65	Sunbeach to Devereaux Creek Spit	Remove the small concrete pool, boat ramp, fill, and bulkhead at Lynch Cove Community Park to restore lost salt marsh.	4	1	3	3	11	150436
74	Sunset Beach to Twanoh State Park	Remove the intertidal fill at the mouth of Twanoh Falls Creek; recreate natural channel geometry and tidal functions.	3	1	4	3	11	151724
77	Twanoh State Park to Union	Remove bulkhead along Alderbrook Creek estuary and restore the historic inlet.	4	1	3	3	11	152118
78	Twanoh State Park to Union	Restore riparian vegetation along Alderbrook Creek below SR 106.	4	2	3	2	11	152118
79	Twanoh State Park to Union	Evaluate tidal exchange at the mouth of "Big Bend Creek," and replace culvert with bridge if natural processes are hindered by the culvert and road fill.	4	2	3	2	11	152122a

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
1	Foulweather Bluff to Point Julia	Restore lost salt marsh and lagoon habitat at the spit 0.5 miles south of the Foulweather Bluff salt marsh. Restore sediment depositional processes by removing bulkheads at this spit.	1	3	3	3	10	142740
13	Point Julia to Teekalet	Remove old pilings, abandoned dock, and fill on the west shoreline about 1.3 miles north of the head of Gamble Bay.	1	3	3	3	10	143956 144006
18	Teekalet Bluff to Warrenville Mudflat	Where possible, restore riparian vegetation at the mouth of Kinman Creek and improve tidal influence to the stream.	1	2	4	3	10	144400
20	Teekalet Bluff to Warrenville Mudflat	Remove the Lofall ferry terminal.	1	2	4	3	10	144410
22	Teekalet Bluff to Warrenville Mudflat	Manage Floral Point remediation/restoration site to limit containment but improve riparian and sediment processes.	1	3	3	3	10	144656
50	Mouth of Dewatto Bay to Bald Point	Remove old pilings in Dewatto Bay, near Red Bluff, and on the Rendsland Creek delta.	4	1	2	3	10	144700 144928 145104 145118
70	Devereaux Creek Spit to Sunset Beach	Restore the natural estuary of Lakewood Creek (Springbrook Creek) and install a bridge under SR 106 to allow tidal influence upstream.	3	1	4	2	10	151512
71	Sunset Beach to Twanoh State Park	Restore tidal function at the mouth of Holyoke Creek by installing a bridge.	3	1	4	2	10	151530

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
72	Sunset Beach to Twanoh State Park	Restore tidal function at the mouth of Happy Hollow Creek by installing bridge.	3	1	4	2	10	151628
73	Sunset Beach to Twanoh State Park	Restore tidal processes and anadromous fish access to “Rearing Pond Creek,” (about 0.17 miles east of stream #14.0130) by removing barriers and assessing road crossing.	3	1	4	2	10	151646
80	Twanoh State Park to Union	Remove derelict barge at mouth of Big Bend Creek.	4	1	2	3	10	152122a
81	Twanoh State Park to Union	Remove old creosoted pilings at Union Marina.	4	1	2	3	10	152400 152346
6	Foulweather Bluff to Point Julia	Remove abandoned barge just north of Point Julia	1	2	3	3	9	143420
14	Point Julia to Teekalet	Remove old section of Hood Canal Bridge from Port Gamble Bay.	1	2	3	3	9	144016
27	Teekalet Bluff to Warrenville Mudflat	Investigate and reduce potential impacts from berm on north edge of King Spit.	2	2	3	2	9	144938
76	Twanoh State Park to Union	When replacement is necessary, convert the Twanoh State Park boat ramp to an elevated design to allow sediment transport and enhance juvenile salmonid migration.	3	1	3	2	9	151820
5	Foulweather Bluff to Point Julia	Remove the impacts to habitat forming processes at access area south of the mouth of Shipbuilders Creek.	1	1	3	3	8	143412

ID Number	Shoreline Reach	Action Recommendation	Proximity to Priority Watersheds (max 5)	Spatial Scale (max 5)	Ecological Scale (max 5)	Temporal Scale (max 3)	Total (max 18)	Ecology Photo Number[1]
7	Foulweather Bluff to Point Julia	On Point Julia, remove the north boat ramp and associated bridge over a tidal channel; reduce total boat ramps to one; minimize the footprint of the road, parking lot, and fill; remove unused materials along the access road to encourage revegetation.	1	2	3	2	8	143440
9	Point Julia to Teekalet	Restore tidal processes and fish access in Little Boston Creek.	1	1	4	2	8	143444
12	Point Julia to Teekalet	Evaluate potential impacts of culvert at the mouth of Gamble Creek, and redesign as necessary.	1	1	4	2	8	143748
26	Teekalet Bluff to Warrenville Mudflat	Remove old pilings north of King Spit.	2	1	2	3	8	144924
43	Anderson Cove to Chinom Point	Eradicate invasive Japanese Knotweed from Anderson Cove.	4	1	2	1	8	151622
10	Point Julia to Teekalet	Remove old pilings about 0.7 miles south of Point Julia.	1	1	2	3	7	143500
11	Point Julia to Teekalet	Protect the inlet of Martha John Creek and remove overwater structures and grounding docks at the mouth of the stream.	1	1	2	3	7	143704
Note: 1. Ecology photos from (Washington Department of Ecology 2000b) NR = Not rated; NA = Not Applicable								

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APPENDIX A: GLOSSARY

‰: Parts per thousand, typically used to express the salinity of water.

Adfluvial: Life history strategy in which adult fish spawn and juveniles subsequently rear in streams, but migrate to lakes for feeding as subadults and adults. Compare to *fluvial*.

Advanced outwash: Sediments sorted and deposited by a stream draining the terminus of an advancing glacier.

Alevin: Juvenile salmonid that has hatched from the egg and remains hidden in the gravel feeding on its yolk sac.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Anadromous fish: Species that hatch in freshwater, mature in saltwater, and return to freshwater to spawn.

Aquifer: Water-bearing rock formation or other subsurface layer.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel. For the purposes of this report refers to the entirety of Water Resource Inventory Area 14.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one species.

Channelization: Straightening the meanders of a river, often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Stability: Tendency of a stream channel to remain within its existing location and alignment.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confluence: Point at which two water bodies join. Often referred to as the “mouth” of a stream or river.

Connectivity: Unbroken linkages in a landscape, often referred to in the context of mainstem connection with side-channels.

Critical Stock: A stock of fish experiencing production levels so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock, and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed or floodplain.

Distributaries: Divergent channels of a stream typically occurring in a delta or estuary.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Endangered Species Act: A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

Endangered Species: Means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of the Endangered Species Act would present an overwhelming and overriding risk to man.

Epibenthic feeding: Foraging strategy that involves capturing prey living on the surfaces of the substrate and aquatic plants in the nearshore zone of the estuary, typically in water with a maximum depth of about two meters (6.6 feet).

Escapement: Those fish that have survived all sources of mortality (natural predation, disease, physiological damage, and fisheries) and return to reproduce.

Estuary: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water. In this case, the entirety of Hood Canal is an estuary.

Eutrophic: Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area (i.e. local extinction). For example, a run of fish may be extinct in a particular watershed, but the species as a whole still persists.

Extinction: The elimination of a species throughout all or a significant portion of its range.

Fingerling: Juvenile salmonid that has grown from the fry stage to a length about the length of a finger.

Flood: An abrupt increase in water discharge; typically flows that overtop streambanks.

Floodplain: A level area adjacent to a stream, constructed through deposition of sediments during the present climate and subject to overland flow during moderate flow events. The floodplain may be abandoned if the climate becomes more arid and is then referred to as a terrace (Leopold 1994).

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Pertaining to streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare to *adfluvial*.

Fry: Juvenile salmonid that has absorbed its yolk sac and swum up out of the gravel to actively feed in the stream.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically, and geologically similar habitats. A GDU may consist of a single stock.

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrograph: Chart of water levels over time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Instream Flow Incremental Methodology: Flow modeling methodology used to determine incremental gains in fish habitat, for individual species, at different flow levels.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare *perennial strea*m.

Interspecific interactions: Interactions between different species.

Intraspecific interactions: Interactions within a species.

Iteroparous fish: Fish (such as steelhead) that are capable of repeat spawning. Spawned-out steelhead returning to the ocean are called "kelts." Compare to *semelparous*.

Kelt: A spawned-out fish (such as a steelhead or cutthroat trout) returning to the ocean.

Lacustrine sediments: Fine silts and clays that settled out of suspension and accumulated on the bottom of a pond or lake.

Large Woody Debris (LWD): Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. Usually refers to pieces at least 20 inches (51 cm) in diameter.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass failure: Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

Morainal sediments: Unconsolidated piles of boulders, cobbles, gravels, sands, and clays deposited at the terminus of a rapidly melting glacier.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Neritic Zone: Waters overlying the continental shelf.

Neritic feeding: Feeding strategy that involves capturing prey in the deeper open waters of the estuary.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt.*

Piscivorous: Feeding habitat that includes consumption of fish.

Plunge pool: Basin scoured out by vertically falling water.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recessional outwash: Sediments sorted and deposited by a stream draining from the terminus of a receding glacier.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redd: A collection of nests or egg pockets characterized by clean gravel and a depression in the streambed created by the digging actions of a spawning female salmonid.

Resident fish: Fish species that complete their entire life cycle in the same geographic area. All lifestages are found in the same habitat. In contrast, anadromous, adfluvial, and fluvial fish lifestages are found in different habitats.

Residual pool depth: The depth of a pool if it is isolated within a dry streambed. Visualize a pool scoured in the streambed. There is water flowing over the streambed upstream and downstream and filling the pool. Now stop the flow of water. Residual pool depth is the depth of water remaining in the isolated pool after the flow of water is stopped.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

Salmonid: Fish of the family Salmonidae, including the Salmoninae (salmon, trout, and char), Coregoniane (whitefish), and Thymallinae (graylings). Characterized by streamlined body, forked tail, and adipose fin. Typically inhabit cold waters.

Salmon: <u>For purposes of this report</u>, refers to all species of the genus *Oncorhynchus* (i.e. chinook, coho, chum, pink, sockeye, rainbow/steelhead trout, and coastal cutthroat trout). The enabling legislation (RCW 77) refers to all members of the family Salmonidae (see “salmonid” above). Whitefish will not be discussed, and grayling and char (bull trout and Dolly Varden) are not known to be present in west WRIA 15 or north WRIA 14.

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Semelparous: Fish (such as the five species of Pacific salmon that occur in Washington) that spawn only once, then die. Compare with *iteroparous*.

Side channel: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to adapt from life in freshwater to life in the sea.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originate from specific watersheds as juveniles and generally return to their birth stream to spawn as adults.

Stream reach: Section of a stream between two points.

Subbasin: <u>For purposes of this report</u> the area encompassed within each of the following drainages: Port Gamble, Big Beef-Anderson, Tahuya-Dewatto, Union-Mission, and North WRIA 14.

Subestuary: The portion of Hood Canal (the estuary) associated with an individual stream mouth. For example, the portions of Hood Canal that receive freshwater from the Union River, Tahuya River, Dewatto River, and Big Beef Creek would each be a subestuary.

Terrace: An abandoned floodplain created during a wetter climate (for example, a period of rapidly receding glaciers).

Thalweg: Portion of a stream or river with deepest water and greatest flow.

Threatened Species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Toe width: A method used to estimate instream flows necessary to provide habitat for salmon and steelhead. It was developed in the 1970s in western Washington by the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG). The method is based on statistical regressions of habitat, as measured in pilot studies based on actual fish habitat selection, on stream channel widths measured between the toes of the banks. Toes of the bank in riffle areas are indicated by change in cross-section slope, change in substrate, and sometimes by vegetation change. The toe width (usually an average of multiple measurements) is plugged into formulas for juveniles and spawners of different species of salmon and steelhead.

Watershed: Entire area that contributes both surface and ground water to a particular, stream, lake or ocean. Scale can vary dramatically depending upon the size of the receiving water body analyzed. For purposes of this report refers to individual streams and all of the associated tributaries within the drainage.

Watershed rehabilitation: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare *watershed restoratio*n.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat.

APPENDIX B: MAPS

APPENDIX C: SALMONID PRODUCTION STREAMS

Table 34. West WRIA 15 and North WRIA 14 Salmonid Production Streams.

Stream Name	Stream Number	Confluence (River Mile)	Receiving Body	Bank
		West WRIA 15		
Hawks Hole Creek	15.0347	NA	Hood Canal	East
Jukes Creek	15.0348	NA	Hood Canal	East
Shipbuilders Creek	15.0349	NA	Hood Canal	East
Little Boston Creek	15.0350	NA	Port Gamble Bay	East
Unnamed Stream	15.0351	0.9	Little Boston Creek	Left
Middle Creek	15.0352	NA	Port Gamble Bay	East
Martha John Creek	15.0353	NA	Port Gamble Bay	East
Unnamed Stream	15.0354	0.25	Martha John Creek	Right
Unnamed Stream	15.0355	0.1	15.0354	Left
Gamble Creek	15.0356	NA	Port Gamble Bay	South
Unnamed Stream	15.0357	2.45	Gamble Creek	Right
Unnamed Stream	15.3058	3.0	Gamble Creek	Left
Todhunter Creek	15.0360	NA	Port Gamble Bay	West
Ladine DeCouteau Creek	Unnumbered	NA	Port Gamble Bay	West
Machias Creek	Unnumbered	NA	Hood Canal	East
Spring Creek	15.0364	NA	Hood Canal	East
Cougar Creek	15.0367	0.3	Kinman Creek	Right
Kinman Creek	15.0368	NA	Hood Canal	East
Jump Off Joe Creek	15.0369	NA	Hood Canal	East
Cattail Creek	15.0370	NA	Hood Canal	East
Unnamed Stream	15.0370A	0.75	Cattail Creek	Right
Unnamed Stream	15.0371	NA	Hood Canal	East
Unnamed Stream	15.0372	NA	Hood Canal	East
Unnamed Stream	15.0373	NA	Hood Canal	East
Devils Hole Creek	15.0374	NA	Hood Canal	East
Unnamed Stream	15.0374A	0.4	Devils Hole Creek	Right
Unnamed Stream	15.0376	NA	Hood Canal	East
Little Anderson Creek	15.0377	NA	Hood Canal	East
Unnamed Stream	15.0378	0.1	Little Anderson Creek	Right
Unnamed Stream	15.0379	0.3	Little Anderson Creek	Left
Unnamed Stream	15.0380	0.4	Little Anderson Creek	Right
Unnamed Stream	15.0382	0.5	Little Anderson Creek	Right
Unnamed Stream	15.0382A	0.45	15.0382	Right
Unnamed Stream	15.0383	0.4	15.0382	Right
Unnamed Stream	15.0385	0.6	15.0382	Left
Unnamed Stream	15.0386	0.8	15.0382	Left
Johnson Creek	15.0387	NA	Hood Canal	East
Big Beef Creek	15.0389	NA	Big Beef Harbor	South
Unnamed Stream	15.0389A	5.7	Big Beef Creek (Lake Symington)	Left
Unnamed Stream	15.0390	0.85	Big Beef Creek	Right

Stream Name	Stream Number	Confluence (River Mile)	Receiving Body	Bank
Unnamed Stream	150394	3.0	Big Beef Creek	Right
Unnamed Stream	15.0396	4.5	Big Beef Creek	Right
Unnamed Stream	15.0397	6.6	Big Beef Creek	Right
Unnamed Stream	15.0398	7.8	Big Beef Creek	Left
Little Beef Creek	15.0399	NA	Little Beef Harbor	South
Seabeck Creek	15.0400	NA	Seabeck Bay	South
Unnamed Stream	15.0400A	0.05	Seabeck Creek	Right
Unnamed Stream	15.0400B	0.0	15.04000A	Left
Unnamed Stream	15.0400C	2.9	Seabeck Creek	Right
Unnamed Stream	15.0400D	3.3	Seabeck Creek	Left
Dancing Feet Creek	15.0400E	NA	Nicks Lagoon (Seabeck Bay)	South
Nicks Creek	15.0400F	NA	Nicks Lagoon (Seabeck Bay)	South
Unnamed Stream	15.0401	0.9	Seabeck Creek	Right
Unnamed Stream	15.0401A	0.2	15.0401	Right
Unnamed Stream	15.0402	1.5	Seabeck Creek	Left
Unnamed Stream	15.0403	NA	Stavis Bay	East
Big Cedar Creek	15.0403A	NA	Hood Canal	East
Stavis Creek	15.0404	NA	Stavis Bay	South
Unnamed Stream	15.0404A	2.6	Stavis Creek	Right
Unnamed Stream	15.0404B	3.6	Stavis Creek	Left
Unnamed Stream	15.0404B1	0.2	15.0404B	Left
Unnamed Stream	15.0404C	4.0	Stavis Creek	Left
Unnamed Stream	15.0404D	4.3	Stavis Creek	Right
Unnamed Stream	15.0405	0.5	Stavis Creek	Left
Unnamed Stream	15.0405A	1.8	15.0405	Left
Unnamed Stream	15.0406	1.1	15.0405	Right
Boyce Creek	15.0407	NA	Hood Canal	East
Harding Creek	15.0408	NA	Hood Canal	East
Unnamed Stream	15.0409	0.6	Harding Creek	Right
Unnamed Stream	15.0410	0.7	Harding Creek	Right
Unnamed Stream	15.0411	0.7	Harding Creek	Left
Anderson Creek	15.0412	NA	Anderson Cove	East
Unnamed Stream	15.0412A	NA	Anderson Cove	South
Unnamed Stream	15.0412B	0.1	Anderson Creek	Left
Unnamed Stream	15.0412C	0.2	Anderson Creek	Left
Unnamed Stream	15.0412D	1.1	Anderson Creek	Left
Unnamed Stream	15.0412E	1.3	Anderson Creek	Right
Unnamed Stream	15.0412F	1.35	Anderson Creek	Left
Unnamed Stream	15.0412G	2.35	Anderson Creek	Right
Unnamed Stream	15.0412H	0.4	Anderson Creek	Right
Unnamed Stream	15.0413	0.6	Anderson Creek	Left
Unnamed Stream	15.0414	1.65	Anderson Creek	Left
Unnamed Stream	15.0414A	0.7	15.0414	Right
Unnamed Stream	15.0415	0.2	15.0414	Right
Unnamed Stream	15.0416	2.7	Anderson Creek	Left

Stream Name	Stream Number	Confluence (River Mile)	Receiving Body	Bank
Thomas Creek	15.0417	NA	Hood Canal	East
Unnamed Stream	15.0418	NA	Hood Canal	East
Dewatto River	15.0420	NA	Dewatto Bay	East
Unnamed Stream	15.0420A	NA	Dewatto Bay	South
Unnamed Stream	15.0420B	0.01	Dewatto River	Right
Unnamed Stream	15.0420C	0.8	Dewatto River	Left
Unnamed Stream	15.0420D	1.9	Dewatto River	Right
Unnamed Stream	15.0420E	2.1	Dewatto River	Right
Unnamed Stream	15.0420F	7.1	Dewatto River	Right
Unnamed Stream	15.0420F1	0.05	15.0420F	Left
Unnamed Stream	15.0420G	8.3	Dewatto River	Left
Unnamed Stream	15.0420H	8.45	Dewatto River	Left
Unnamed Stream	15.0420I	8.5	Dewatto River	Right
Unnamed Stream (small wetland)	15.0420I1	0.6	15.0420I	Right
Unnamed Stream	15.0420J	8.75	Dewatto River	Right
White Creek	15.0421	0.5	Dewatto River	Left
Unnamed Stream	15.0422	0.25	White Creek	Right
Huson Creek	15.0423	2.25	Dewatto River	Right
Shoe Creek	15.0424	2.5	Dewatto River	Left
Unnamed Stream	15.0425	0.55	Shoe Creek	Right
Alder Creek	15.0426	3.5	Dewatto River	Left
South Fork Alder Creek	15.0427	0.85	Alder Creek	Left
Unnamed Stream	15.0428	4.2	Dewatto River	Left
Unnamed Stream	15.0429	4.6	Dewatto River	Right
Unnamed Stream	15.0431	1.2	15.0429	Right
Unnamed Stream	15.0432	1.35	15.0429	Left
Unnamed Stream	15.0433	5.5	Dewatto River	Left
Unnamed Stream	15.0434	5.9	Dewatto River	Right
Unnamed Stream	15.0434A	0.6	15.0434	Right
Unnamed Stream	15.0434B	0.85	15.0434	Left
Ludvick Lake Creek	15.0435	6.4	Dewatto River	Left
Unnamed Stream	15.0435A	0.6	Ludvick Lake Creek	Right
Windship Creek	15.0436	7.7	Dewatto River	Left
Erickson Lake Outlet	15.0437	0.35	Windship Creek	Right
Little Dewatto Creek	15.0438	NA	Hood Canal	East
Rendsland Creek	15.0439	NA	Hood Canal	East
Unnamed Stream	15.0439A	2.45	Rendsland Creek	Right
Unnamed Stream	15.0439B	3.15	Rendsland Creek	Left
Unnamed Stream	15.0439C	3.3	Rendsland Creek	Right
Unnamed Stream	15.0439D	3.6	Rendsland Creek	Left
Unnamed Stream	15.0439E	5.5	Rendsland Creek	Left
Unnamed Stream	15.0440	0.25	Rendsland Creek	Left
Unnamed Stream	15.0441	2.65	Rendsland Creek	Right
Unnamed Stream	15.0442	3.7	Rendsland Creek	Right
Unnamed Stream	15.0443	3.61	Rendsland Creek	Left

Stream Name	Stream Number	Confluence (River Mile)	Receiving Body	Bank
Browns Creek	15.0444	NA	Hood Canal	North
Unnamed Stream	15.0526[a]	NA	Hood Canal	North
Caldervin Creek	15.0445	NA	Hood Canal	North
Tahuya River	15.0446	NA	Hood Canal	North
Unnamed Stream	15.0446A	1.5	Tahuya River	Right
Unnamed Stream	15.0446B	2.3	Tahuya River	Right
Unnamed Stream	15.0446C	2.55	Tahuya River	Left
Unnamed Stream	15.0446D	3.0	Tahuya River	Right
Unnamed Stream	15.0446E	3.35	Tahuya River	Right
Unnamed Stream	15.0446F	3.65	Tahuya River	Right
Unnamed Stream	15.0446G	3.85	Tahuya River	Right
Unnamed Stream	15.0446H	6.7	Tahuya River	Left
Unnamed Stream	15.0446I	11.15	Tahuya River	Left
Oak Patch Lake Outlet	15.0446J	12.6	Tahuya River	Left
Unnamed Stream	15.0446K	16.2	Tahuya River	Left
Schoolhouse Creek	15.0447	0.25	Tahuya River	Right
Unnamed Stream	15.0448	0.9	Tahuya River	Right
Howell Lake Outlet	15.0449	4.3	Tahuya River	Right
Unnamed Stream	15.0450	0.8	Howell Lake Outlet	Right
Unnamed Stream	15.0451	4.4	Tahuya River	Right
Unnamed Stream	15.0452	6.35	Tahuya River	Right
Unnamed Stream	15.0453	6.7	Tahuya River	Right
Potholes Creek	15.0454	1.25	15.0457	Right
Unnamed Stream	15.0455	0.4	15.0457	Right
South Spillman Creek	15.0456	1.05	15.0457	Right
Little Tahuya River	15.0457	8.0	Tahuya River	Left
Long Marsh Outlet	15.0491[b]	1.8	15.0457	NA
Andy’s Creek)	15.0458	8.03	Tahuya River	Right
Erdman Lake Outlet	15.0459	9.2	Tahuya River	Right
Christine Lake Outlet	15.0460	9.4	Tahuya River	Right
Haven Lake Outlet	15.0461	0.01	Christine Lake Outlet	Right
Bennettson Lake Outlet	15.0462	0.7	Christine Lake Outlet	Left
Unnamed Stream	15.0463	NA	Christine Lake	North
Christine Lake Inlet	15.0464	NA	Christine Lake	North
Unnamed Stream	15.0465	11.4	Tahuya River	Right
Outlet Creek	15.0466	11.85	Tahuya River	Right
Unnamed Stream	15.0467	1.7	Unnamed Lake	North
Blacksmith Lake Outlet	15.0468	12.15	Tahuya River	Right
Buffon Creek	15.0470	15.2	Tahuya River	Right
Unnamed Stream	15.0470A	0.8	15.0470	Left
Morgan Marsh Outlet	15.0471	16.7	Tahuya River	Right
Unnamed Stream	15.0471A	0.35	15.0471	Left
Panther Creek	15.0472	17.7	Tahuya River	Left
Gold Creek	15.0474	21.05	Tahuya River	Left
Unnamed Stream	15.0474A	2.25	Gold Creek	Right

Stream Name	Stream Number	Confluence (River Mile)	Receiving Body	Bank
Grata Creek	15.0475	21.25	Tahuya River	Left
Tin Mine Creek	15.0476	22.25	Tahuya River	Left
Shoofly Creek	15.0478	NA	Hood Canal	North
Little Shoofly Creek	15.0483	NA	Hood Canal	North
Unnamed Stream	15.0484	0.3	Little Shoofly Creek	Right
Cady Creek	15.0486	NA	Hood Canal	North
Northshore Nursery Creek	15.0487	NA	Hood Canal	North
Stimson Creek	15.0488	NA	Hood Canal	North
Unnamed Stream	15.0488A	1.15	Stimson Creek	Right
Unnamed Stream	15.0489	0.65	Stimson Creek	Right
Unnamed Stream	15.0490	1.05	Stimson Creek	Right
Unnamed Stream	15.0490A	0.3	15.0490	Right
Sundstrom Creek	15.0492	NA	Hood Canal	North
Little Mission Creek	15.0493	NA	Hood Canal	North
Unnamed Stream	15.0494	0.75	Little Mission Creek	Right
Unnamed Stream	15.0494A	1.15	15.0494	Left
Big Mission Creek	15.0495	NA	Hood Canal	North
Unnamed Stream	15.0495A	1.65	Big Mission Creek	Left
Unnamed Stream	15.0495B	6.15	Big Mission Creek	Left
Unnamed Stream	15.0495C	8.65	Big Mission Creek	Right
Unnamed Stream	15.0496	2.65	Big Mission Creek	Left
Unnamed Stream	15.0496A	1.55	15.0496	Left
Unnamed Stream	15.0497	0.95	15.0496	Right
Unnamed Stream	15.0497A	0.3	15.0497	Left
Stringer Creek	15.0498	3.65	Big Mission Creek	Right
Unnamed Stream	15.0499	4.65	Big Mission Creek	Right
Unnamed Stream	15.0500	0.25	15.0499	Right
Unnamed Stream	15.0501	1.35	15.0499	Right
Unnamed Stream	15.0502	8.95	Big Mission Creek	Right
Union River	15.0503	NA	Lynch Cove	East
Unnamed Stream	15.0503A	0.2	Union River	Left
Unnamed Stream	15.0503B	0.65	Union River	Left
Unnamed Stream	15.0503C	0.95	Union River	Right
Unnamed Stream	15.0503D	1.55	Union River	Left
Unnamed Stream	15.0503E	3.4	Union River	Right
Unnamed Stream	15.0503F	4.0	Union River	Right
Unnamed Stream	15.0503G	5.6	Union River	Right
Unnamed Stream	15.0503H	7.1	Union River	Left
Huson Creek	15.0503I	1.25	Union River	Right
Foster Creek	15.0503J	1.95	Union River	Right
Unnamed Stream	15.0504	0.45	Union River	Left
Courtney Creek	15.0505	2.35	Union River	Right
Unnamed Stream	15.0505A	1.4	Courtney Creek	Right
Everson Creek	15.0507	2.7	Union River	Right
Unnamed Stream	15.0507A	0.2	15.0507	Left

Stream Name	Stream Number	Confluence (River Mile)	Receiving Body	Bank
Unnamed Stream	15.0508	3.75	Union River	Right
Bear Creek	15.0510	4.3	Union River	Right
Unnamed Stream	15.0510A	2.5	Bear Creek	Left
Unnamed Stream	15.0510B	2.35	Bear Creek	Left
Airport Creek	15.0512	4.6	Union River	Left
Unnamed Stream	15.0513	0.95	Airport Creek	Right
East Fork Union River	15.0514	5.4	Union River	Left
Unnamed Stream	15.0515	5.85	Union River	Left
Hazel Creek	15.0516	6.0	Union River	Right
Unnamed Stream	15.0517	7.0	Union River	Right
Unnamed Stream	15.0519	8.75	Union River	Left
Unnamed Stream	15.0519A	0.55	15.0519	Right
Unnamed Stream	15.0519B	0.6	15.0519	Left
Unnamed Stream	15.0520	8.75	Union River	Right
Unnamed Stream	15.0521	0.6	15.0520	Left
Unnamed Stream	15.0521A	0.25	15.0521	Right
Unnamed Stream	15.0522	NA	Lynch Cove	East
Alder Creek	15.0523	NA	Lynch Cove	East
Sweetwater Creek	15.0524	NA	Lynch Cove	East
North WRIA 14 (ordered from east to west)				
Devereaux Creek	14.0124	NA	Hood Canal	South
Springbrook (Lakewood) Creek	14.0126	NA	Hood Canal	South
Holyoke Creek	14.0127	NA	Hood Canal	South
Unnamed Stream	14.0129	NA	Hood Canal	South
Unnamed Stream	14.0130	NA	Hood Canal	South
Twanoh Falls Creek	14.0132	NA	Hood Canal	South
Twanoh Creek	14.0134	NA	Hood Canal	South
Unnamed Stream	14.0135	NA	Hood Canal	South
Nordstrom Creek	Unnumbered	NA	Hood Canal	South
Alderbrook Creek	Unnumbered [c]	NA	Hood Canal	South
Dalby Creek	14.0139 [d]	NA	Hood Canal	South
Big Bend Creek	14.0138[e]	NA	Hood Canal	South

Stream number source: (Williams *et al.* 1975). Streams are listed in ascending order of stream number. Stream numbers with a letter suffix do not appear in (Williams *et al.* 1975). These numbers were assigned for use in this report. River miles measured by the author from DNR 1:24,000 hydrography layer using ArcGIS 8.2. River mile numbers may occur out of sequence because of assignment of alphanumeric numbers. **Bold** stream names indicate multiple salmonid producing tributary streams. NA = Not applicable. Right and left bank refer to direction looking downstream. a. This stream is located between Browns and Caldervin Creeks, but the stream number assigned to it is out of sequence. b. This stream is mapped by Williams *et al.* (1975) as a tributary of Stimson Creek, but it actually flows into stream 15.0457. c. Alderbrook Creek, immediately east of Dalby Creek, was mapped by Williams *et al.* (1975) as stream 14.0138, today referred to as Big Bend Creek. d. Dalby Creek is not labeled on Map 2 of this report. The stream is depicted as a right bank tributary of Big Bend Creek, but it actually flows to Hood Canal. e. Big Bend Creek is stream 14.0138, named Alderbrook Creek in Williams *et al.* (1975). See Maps 1 and 2 for exact stream locations.

APPENDIX D: KITSAP PENINSULA SALMONID REFUGIA REPORT HABITAT RATINGS

Table 35. Riverine Habitat Condition Scores from May and Peterson (2002).

Potential Refugia	Stream ID#[a]	Artificial Barriers[1]	Floodplain Conditions[2]	Fine Sediment[3]	Percent Pools[4]	Pool Quality[5]	LWD Quantity	Streambank Stability	Riparian Buffer Width	Riparian Maturity	Riparian Veg-Type	Riparian Condition[6]
Hawks Hole Creek	15.0345	2	2	2	2	2	2	2	3	3	4	3.3
Reservation Creek (Shipbuilders Creek)	15.0349	2	3	2	2	2	2	3	3	3	4	3.3
Little Boston Creek	15.0350	2	2	2	2	2	2	3	3	3	4	3.3
Middle Creek	15.0352	2	3	2	2	2	2	3	3	3	4	3.3
Martha John Creek	15.0353											
RM 0.0-0.5	15.0353	3	3	3	3	3	2	3	2	3	3	2.7
North Tributary	15.0354	3	3	3	3	3	2	4	4	3	3	3.3
RM 0.5-HW	15.0353	3	3	2	3	4	2	3	4	3	3	3.3
Gamble Creek	15.0356											
RM 0.0-1.0	15.0356	3	2	2	2	2	2	1	1	1	1	1.0
RM 1.0-HW	15.0356	3	4	3	4	4	3	3	4	4	4	4.0
Todhunter Creek	15.0360	1	2	3	2	2	2	3	2	3	3	2.7
Ladine DeCouteau Creek	15.0360a	1	2	3	2	2	2	3	2	3	3	2.7
Hudson Creek	15.0361	2	2	3	2	2	2	3	3	3	3	3.0
Cougar Creek	15.0362	2	2	3	2	2	2	3	3	3	3	3.0
Fern Creek	15.0363	2	2	3	2	2	2	3	3	3	3	3.0
Spring Creek	15.0366 (15.0364)	2	2	3	2	2	2	3	3	3	3	3.0

Potential Refugia	Stream ID#[a]	Artificial Barriers[1]	Floodplain Conditions[2]	Fine Sediment[3]	Percent Pools[4]	Pool Quality[5]	LWD Quantity	Streambank Stability	Riparian Buffer Width	Riparian Maturity	Riparian Veg-Type	Riparian Condition[6]
Kinman Creek (Cougar Creek)	15.0367											
RM 0.0-0.5	15.0367	3	2	3	3	3	3	3	3	3	3	3.0
South-Lofall Tributary	15.0367a	2	3	3	3	3	2	3	2	3	3	2.7
North Tributary (Kinman Creek)	15.0368	2	3	2	3	3	2	2	2	3	3	2.7
RM 0.5-HW	15.0367	3	3	3	3	3	3	3	2	3	3	2.7
Jump Off Joe Creek	15.0369	2	2	3	2	2	2	1	2	3	2	2.3
Cattail Creek	15.0370	1	2	3	2	2	2	3	4	4	4	4.0
Devils Hole Creek	15.0374	2	2	3	3	2	2	3	3	4	4	3.7
Bangor Creek (Unnamed Stream)	15.0376	2	2	3	2	2	2	3	2	3	3	2.7
Little Anderson Creek	15.0376											
RM 0.0-0.5	15.0376	3	3	3	3	2	2	2	3	3	3	3.0
RM 0.5-1.0	15.0376	4	3	3	3	2	2	3	2	3	3	2.7
RM 1.0-HW	15.0376	4	3	3	3	2	2	4	4	3	3	3.3
Johnson (Lone Rock) Creek	15.0387	2	2	3	2	2	2	1	2	3	2	2.3
Big Beef Creek	15.0389											
RM 0.0-0.5	15.0389	3	3	3	2	2	2	3	3	3	3	3.0
RM 0.5-5.5	15.0389	4	4	3	3	3	3	4	4	3	3	3.3
Lake Symington RM 5.5-6.0	15.0389	2	1	1	2	2	1	2	2	2	2	2.0

Potential Refugia	Stream ID#[a]	Artificial Barriers[1]	Floodplain Conditions[2]	Fine Sediment[3]	Percent Pools[4]	Pool Quality[5]	LWD Quantity	Streambank Stability	Riparian Buffer Width	Riparian Maturity	Riparian Veg-Type	Riparian Condition[6]
RM 6.0-6.5	15.0389	3	3	4	3	3	3	4	3	4	4	3.7
RM 6.5-HW	15.0389	4	4	3	4	4	3	4	4	3	3	3.3
Little Beef Creek	15.0399	3	3	3	3	3	3	4	3	4	4	3.7
Seabeck Creek	15.0400											
RM 0.0-0.5	15.0400	4	3	4	4	3	3	3	2	3	3	2.7
RM 0.5-1.0	15.0400	3	3	4	3	3	3	3	2	3	3	2.7
Seabeck Heights Tributary	15.0401	2	2	2	1	1	1	1	1	3	3	2.3
RM 1.0-HW	15.0400	4	4	4	3	3	3	3	4	3	3	3.3
Big Cedar Creek (Unnamed Stream)	15.0403	3	4	4	2	3	3	4	4	4	4	4.0
Stavis Creek	15.0404											
RM 0.0-0.5	15.0404	4	4	3	4	3	3	3	4	4	4	4.0
West Fork	15.0405	4	4	3	4	3	3	3	4	4	4	4.0
East Fork	15.0404	4	4	3	4	3	3	2	4	4	4	4.0
Boyce Creek	15.0407	4	3	3	3	3	2	4	4	3	3	3.3
Nellita Creek	15.0407a	4	3	2	2	2	2	4	4	3	3	3.3
Harding Creek	15.0408	4	3	3	3	3	2	4	4	3	3	3.3
Big Anderson Creek	15.0412											
RM 0.0-1.0	15.0412	4	3	3	4	4	3	4	3	3	3	3.0

Potential Refugia	Stream ID#[a]	Artificial Barriers[1]	Floodplain Conditions[2]	Fine Sediment[3]	Percent Pools[4]	Pool Quality[5]	LWD Quantity	Streambank Stability	Riparian Buffer Width	Riparian Maturity	Riparian Veg-Type	Riparian Condition[6]
RM 1.0-1.5	15.0412	4	2	3	3	3	3	2	2	2	3	2.3
South Tributary	15.0413	4	4	3	3	3	3	4	3	3	3	3.0
South Fork	15.0414	4	4	3	2	2	2	3	2	2	3	2.3
North Fork	15.0412	4	4	3	2	2	2	3	2	2	3	2.3
Thomas Creek	15.0417	3	3	3	2	2	2	3	3	3	2	2.7
Dewatto River	15.0420											
RM 0.0-1.0	15.0420	4	3	4	4	4	4	4	3	3	4	3.3
RM 1.0-4.0	15.0420	4	4	4	4	4	4	4	3	3	4	3.3
RM 4.0-HW	15.0420	4	4	4	4	4	4	4	4	3	4	3.7
Cady Lake Creek	15.0421	4	3	4	4	4	3	4	3	3	4	3.3
White Creek	15.0422	4	3	4	4	4	3	4	3	3	4	3.3
Shoe Lake Creek	15.0424	4	3	4	4	4	3	4	3	3	4	3.3
Larsen Lake Creek	15.0425	4	3	4	4	4	3	4	3	3	4	3.3
Alder Creek	15.0426	4	3	4	4	4	3	4	3	3	4	3.3
Ralph Creek	15.0428	4	3	4	4	4	3	4	3	3	4	3.3
Oak Lake Creek	15.0429	4	3	4	4	4	3	4	3	3	4	3.3
Cutthroat Creek	15.0434	4	3	4	4	4	3	4	3	3	4	3.3
Ludvick Lake Creek	15.0435	4	3	4	4	4	3	4	3	3	4	3.3
Blacksmith Creek	15.0436	4	3	4	4	4	3	4	3	3	4	3.3
Erickson Lake Creek	15.0437	4	3	4	4	4	3	4	3	3	4	3.3
Rendsland Creek	15.0439	3	3	3	3	3	3	4	4	3	4	3.7

Potential Refugia	Stream ID#[a]	Artificial Barriers[1]	Floodplain Conditions[2]	Fine Sediment[3]	Percent Pools[4]	Pool Quality[5]	LWD Quantity	Streambank Stability	Riparian Buffer Width	Riparian Maturity	Riparian Veg-Type	Riparian Condition[6]
Brown Creek	15.0444	2	3	3	2	3	3	3	3	3	4	3.3
Caldervin Creek	15.0445	3	3	3	3	3	3	4	4	3	4	3.7
Tahuya River	15.0446											
RM 0.0-1.0	15.0446	3	2	4	4	3	3	2	3	3	3	3.0
RM 1.0-4.0	15.0446	4	3	4	4	3	3	3	3	3	3	3.0
RM 4.0-8.0	15.0446	4	3	4	4	3	3	3	4	3	3	3.3
RM 8.0-16.0	15.0446	4	4	4	4	3	3	4	4	3	3	3.3
RM 16.0-HW	15.0446	4	4	4	4	3	3	4	4	3	3	3.3
Little Tahuya Creek	15.0454	3	4	4	4	4	3	4	4	3	3	3.3
Andy Creek	15.0458	4	3	4	3	4	3	4	4	3	3	3.3
Erdman Creek	15.0459	4	3	4	3	4	3	4	4	3	3	3.3
Haven Lake Creek	15.0461	4	3	4	3	4	3	4	4	3	3	3.3
Twin Lake Creek	15.0463	4	3	4	3	4	3	4	4	3	3	3.3
Outlet Creek	15.0466	4	3	4	3	4	3	4	4	3	3	3.3
Blacksmith Lake Creek	15.0468	4	3	4	3	4	3	4	4	3	3	3.3
Buffoon Creek	15.0470	4	3	4	3	4	3	4	4	3	3	3.3
Morgan Marsh Creek	15.0471	4	3	4	3	4	3	4	4	3	3	3.3
Panther Lake Creek	15.0472	4	3	4	3	4	3	4	4	3	3	3.3
Gold Creek	15.0474	4	3	4	3	4	3	4	4	3	3	3.3
Grata Creek	15.0475	4	3	4	3	4	3	4	4	3	3	3.3
Tin Mine Creek	15.0476	4	3	4	3	4	3	4	4	3	3	3.3
Shoofly Creek	15.0478	2	3	3	2	3	3	3	3	3	4	3.3

Potential Refugia	Stream ID#[a]	Artificial Barriers[1]	Floodplain Conditions[2]	Fine Sediment[3]	Percent Pools[4]	Pool Quality[5]	LWD Quantity	Streambank Stability	Riparian Buffer Width	Riparian Maturity	Riparian Veg-Type	Riparian Condition[6]
Little Shoofly Creek	15.0483	2	3	3	2	3	3	3	3	3	4	3.3
Cady Creek	15.0486	2	3	3	2	3	3	3	3	3	4	3.3
Stimson Creek	15.0488	2	2	3	2	3	3	3	2	3	4	3.0
Hall Creek	15.0491	2	3	3	2	3	3	3	2	3	4	3.0
Johnson Creek (Sundstrom Creek)	15.0492	2	3	3	2	3	3	3	2	3	4	3.0
Little Mission Creek	15.0493											
RM 0.0-0.5	15.0493	4	3	4	3	3	3	4	4	4	4	4.0
RM 0.5-HW	15.0493	4	4	4	3	3	3	4	4	4	3	3.7
Big Mission Creek	15.0495											
RM 0.0-0.5	15.0495	4	2	4	3	3	3	3	2	2	3	2.3
RM 0.5-2.5	15.0495	4	3	4	3	3	3	4	3	3	3	3.0
RM 2.5-4.0	15.0495	3	3	4	3	3	3	4	3	3	3	3.0
RM 4.0-HW	15.0495	3	3	4	3	3	3	4	3	3	3	3.0
Union River	15.0503											
RM 0.0-1.0	15.0503	3	2	3	3	3	3	2	2	3	3	2.7
RM 1.0-5.0	15.0503	3	3	3	4	3	3	3	2	3	3	2.7
RM 5.0-HW	15.0503	3	3	3	4	3	3	4	3	3	3	3.0
Courtney Creek	15.0505	3	3	3	4	3	3	4	3	3	3	3.0
Bear Creek	15.0510	3	3	3	4	3	3	4	3	3	3	3.0
Airport Creek	15.0514	2	3	3	3	3	3	3	2	3	3	2.7
Hazel Creek	15.0516	3	3	3	4	3	3	4	3	3	3	3.0

Table 35 Legend	
1. “Migration Access” in May and Peterson (2002) 2. Includes floodplain connectivity and loss of floodplain habitat. 3. “Spawning Habitat Quality” in May and Peterson (2002) Note: May and Peterson (2002) Habitat score key: 1= Poor; 2 = Fair; 3 = Good; 4 = Optimal. The “optimal” category is not used in this report. <u>In most cases, the criteria used by May and Peterson (2002) to rate habitat conditions differ from the criteria used in this report. Therefore, in many cases, habitat condition ratings in this report will not agree with those of May and Peterson (2002).</u>	4. “Rearing Habitat Quantity” in May and Peterson (2002) 5. “Rearing Habitat Quality” in May and Peterson (2002) 6. Mean of Riparian Maturity and Riparian Veg-Type columns, calculated by author for use in this report. <u>For rating purposes in this report, a mean value of 4 = good, 3.7 = good to fair, 3.3 to 3.0 = fair, 2.7 to 2.3 = fair to poor, and 2.0 or less equals poor.</u> a. Note that some stream names and numbers used in May and Peterson (2002) differ from those used in this report. Names or numbers in parenthesis correspond to those used in this report.

Table 36. Habitat Assessment Score Sheet from May and Peterson (2002).

Habitat Parameter (Score)	Optimal (4)	Good (3)	Fair (2)	Poor (1)
Migration Access (Artificial Barriers)	All Habitat Accessible	<10% Blocked	10-20% Blocked	>20% Blocked
Floodplain Conditions (Habitat & Connectivity)	Natural Floodplain	<25% Area Altered or Lost	25-50% Area Altered or Lost	>50% Area Altered or Lost
Spawning Habitat Quantity (% Riffles)	40-60% Balanced P-R	30-40% Few Riffles	20-30% Sparse Riffles	<20% Glide Dominated
Spawning Habitat Quality (% Fines & Embeddedness)	<10% Cobble/Gravel	10-15% Gravel/Sand	15-20% Sand/Gravel	>20% Sand/Silt
Rearing Habitat Quantity (% Pools)	40-60% Balanced P-R	30-40% Few Pools	20-30% Sparse Pools	<20% Glide Dominated
Rearing Habitat Quality (Depth & Cover)	Frequent Deep Pools w/Cover	Some Deep Pools and Good Cover	Few Deep Pools Little Cover	No Deep Pools Little/No Cover
LWD Quantity (Large Woody Debris)	Abundant Complex	Moderate Spotty	Sparse Infrequent	Little or No LWD
LWD Quality (Large Woody Debris)	Coniferous Large (Key)	Mixed Medium	Deciduous Small	Little or No LWD
Streambank Stability (Bank Erosion)	Stable (>90%) Fully Vegetated	75-90% Stable Patchy Vegetation	50-75% Stable Sparse Vegetation	Unstable (<50%) or riprap
Streambed Stability (Scour and Fill)	Stable Natural Changes	Localized Scour and Fill	Degradation Aggradation	Unstable Frequent Changes
Channel Form (Shape/Sinuosity	Natural Diverse/Complex	Flow-impacted Meandering	Flow Incised or Constrained	Channelized or Ditched
Riparian Buffer Width (w/in SPTH)	Wide/Intact Continuous	Some Encroachment	Narrow Fragmented	Frequent Encroachment
Riparian Quality (Stand-Age)	Mature Forest >20" dbh	Mixed Forest 12-20" dbh	Young Forest <12" dbh	Little/No Forest Shrub/Brush
Dominant Vegetation (w/in 50m)	Conifer Dominated	Mixed Conifer/Deciduous	Deciduous Dominated	Grass/Shrub Invasives
Canopy Cover (Temperature Control)	Dense/Shaded Natural Temp	Filtered Periodic Hi Temp	Sunlight Frequent Hi Temp	Sparse/Broken Elevated Temp

APPENDIX E: NEARSHORE MAN-MADE STRUCTURES

Table 37. Nearshore Man-Made Structures.

Driftcell ID[a]	Driftcell Name[a,b]	Docks[b]	Jetties[b]	Launch Ramps[b]	Rail Launches[b]	Stairs[b]
Foulweather Bluff to Point Julia						
1411	KS-1-3	0	0	0	0	0
1412	KS-1-3/KS-1-4	0	0	0	0	0
1413	KS-1-4	1	0	0	1	2
1414	KS-1-4/KS-1-5	0	0	0	0	1
1415	KS-1-5	0	0	1	0	1
1416	KS-1-5/KS-1-6	44	0	0	0	0
1417	KS-1-6	0	0	0	0	6
1418	KS-1-6/KS-1-7	0	0	0	0	0
1419	KS-1-7	0	0	2	0	1
1420	KS-1-7/KS-2-2	1	0	0	0	0
	Totals	46	0	3	1	11
Point Julia to Teekalet Bluff						
1421	KS-2-2	0	0	0	0	2
1422	KS-2-2/KS-2-3	0	0	0	0	4
1423	KS-2-3	6	0	0	0	5
1424	KS-2-3/KS-2-4	0	0	0	0	0
1425	KS-2-4	0	0	1	0	2
1426	KS-2-4/KS-2-5	2	1	0	0	0
	Totals	8	1	1	0	13
Teekalet Bluff to Warrenville Mudflat						
1427	KS-2-5	17	0	7	9	51
1428	KS-2-5	-	-	-	-	-
1429	KS-2-5	-	-	-	-	-
	Totals	17	0	7	9	51
Warrenville Mudflat to Misery Point						
1430	KS-2-5/KS-5-2	17	0	0	1	1
1431	KS-5-2	4	0	2	15	3
1432	KS-5-2/KS-6-2	0	0	0	0	0
1433	KS-6-2	0	0	1	2	4
	Totals	21	0	3	18	8
Misery Point to Hood Point						
1434	KS-6-2/KS-6-3	0	0	0	0	0
1435	KS-6-3	0	0	1	0	8
1436	KS-6-3/KS-6-4	0	0	0	0	0
1437	KS-6-4	0	0	0	0	0
1438	KS-6-4/KS-6-5	0	0	0	0	0
1439	KS-6-5	0	0	0	0	1
1440	KS-6-5/KS-7-2	0	0	0	0	0
	Totals	0	0	1	0	9

Driftcell ID[a]	Driftcell Name[a,b]	Docks[b]	Jetties[b]	Launch Ramps[b]	Rail Launches[b]	Stairs[b]
Hood Point to Anderson Cove						
1441	KS-7-2	0	0	0	0	0
1442	KS-8-1	0	0	0	0	0
1443	KS-7-2/KS-8-2	0	0	0	0	0
1444	KS-8-2	1	0	0	0	0
1445	KS-8-2/KS-8-3	0	0	0	0	0
1446	KS-8-3	1	0	0	0	1
	Totals	2	0	0	0	1
Anderson Cove to Chinom Point						
1447	KS-8-3/KS-8-4	0	0	0	0	0
1448	KS-8-4	1	0	2	0	0
1449	KS-8-4/KS-9-2	0	0	0	0	0
1450	KS-9-2	0	0	0	0	0
1451	KS-9-2/KS-9-3	0	0	0	0	0
	Totals	1	0	2	0	0
Chinom Point to Mouth of Dewatto Bay						
1452	KS-9-3	0	0	0	0	4
1237	KS-9-3	-	-	-	-	-
1238	MA-4-6	-	-	-	-	-
	Totals	0	0	0	0	4
Mouth of Dewatto Bay to Bald Point						
1239	MA-4-5/MA-4-6	0	0	0	0	1
1240	MA-4-5	0	0	0	0	1
1241	MA-4-4/MA-4-5	3	0	0	0	0
1242	MA-7-1	2	0	2	0	3
1243	MA-7-1	0	0	0	1	0
	Totals	5	0	2	1	5
Bald Point to Sisters Point						
1244	MA-7-1/MA-7-2	0	0	0	1	0
1245	MA-8-1	5	0	2	2	0
1246	MA-8-1/MA-8-2	1	0	0	0	0
1247	MA-8-2	0	0	2	0	0
1248	MA-8-2/MA-8-3	1	0	7	2	0
1249	MA-9-1	5	1	7	15	0
	Totals	12	1	18	20	0
Sisters Point to Northshore Gravel Pit						
1250	MA-9-2	0	0	0	0	0
1251	MA-9-2/MA-9-3	2	0	0	0	0
1252	MA-9-3	0	0	0	0	0
1253	MA-9-4	0	0	0	1	0
1254	MA-9-4/MA-9-5	1	0	0	0	0
1255	MA-10-1	1	0	1	0	0
1256	MA-10-2	3	0	0	0	0
1257	MA-10-3	3	0	0	0	0
	Totals	10	0	1	1	0

Driftcell ID[a]	Driftcell Name[a,b]	Docks[b]	Jetties[b]	Launch Ramps[b]	Rail Launches[b]	Stairs[b]
Northshore Gravel Pit to Sunbeach						
1258	MA-10-4	0	0	0	0	0
1259	MA-10-4/MA-10-5	0	0	0	1	0
1260	MA-11-1	0	6	8	0	0
1261	MA-11-2	4	0	1	0	0
1262	MA-11-2/MA-11-3	2	1	0	0	0
	Totals	6	7	9	1	0
Sunbeach to Devereaux Creek Spit						
1263	MA-11-3/MA-11-6	0	0	1	0	0
1264	MA-11-3/MA-11-6	-	-	-	-	-
	Totals	0	0	1	0	0
Devereaux Creek Spit to Sunset Beach						
1265	MA-11-6	7	0	2	0	0
1266	MA-11/5/MA-11-6	5	0	0	0	0
1267	MA-11-5	5	0	1	0	0
	Totals	17	0	3	0	0
Sunset Beach to Twanoh State Park						
1268	MA-10-8	39	0	7	2	0
1269	MA-10-7/MA-10-8	2	0	0	0	0
1270	MA-10-7	1	0	1	0	1
	Totals	42	0	8	2	1
Twanoh State Park to Union						
1271	MA-8-6	63	1	1	1	0
1272	MA-8-5/MA-8-6	3	0	0	0	0
1273	MA-8-5	2	0	0	0	0
1274	MA-7-4	28	0	2	0	0
	Totals	96	1	3	1	0

Sources: a. (Washington Department of Ecology 2000a) b. (Hirschi *et al.* 2002). See Maps 8 & 9 for driftcell locations.